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THE SURGERY OF THE SPINE.

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BY

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I N endeavoring to systematize the study of the surgery of the spine it has seemed to me well to limit myself to the conditions requiring operative interference, or to those in which operation may reasonably be considered, and to exclude such as lateral curvature, the so-called "railway spine," etc., some of which belong to the province of the orthopædist, others to that of the neurologist.

I may classify those remaining as follows :

- A. Congenital deformities ;
- B. Tuberculosis of the spine ;
- C. Neoplasms ;
- D. Traumatisms.

A. Under the first heading, spina bifida is the only condition which is at once of sufficient frequency and sufficient importance to demand special consideration. I have carefully reviewed the entire subject, and see no reason at present to dissent from the conclusion arrived at by the committee of the Clinical Society of London, and held, I believe, by the majority of surgeons at the present day. This is, that while various successes have been reported by other methods, such as simple tapping and drainage, and more recently in a limited num-

ber of cases by excision of the sac, yet on the whole the method of injection of the sac offers the best prospect of ultimate recovery with the least immediate danger. The method is described as follows :

The sac being cleaned, a syringe which will hold about two drachms of an iodo-glycerin solution is chosen, and a fine trocar. The calibre of this must not be too fine for the thick fluid (iodine, 10 grains ; iodide of potassium, 1 drachm ; glycerin, 1 ounce) which has to pass through it. The puncture in the swelling should be made well at one side, obliquely through healthy skin, and not through the membranous sac-wall, the objects being to avoid wounding the cord or nerves, and also to diminish the risk of leakage of the cerebro-spinal fluid. Unless the sac is very large, it is probably better not to draw off much, if any, of the fluid from the sac on the first occasion. The position of the child during the injection has been a good deal dwelt upon, most authorities recommending that it should be upon its back. The Clinical Society's committee advises that the child should be laid upon its side. About a drachm is the quantity which they recommend. Every care must be taken to prevent any escape of the cerebro-spinal fluid now and later, it being clearly understood that any leakage, which is most difficult to prevent, may lead to septic meningitis and death. When the needle is withdrawn the puncture should be pressed around it, and immediately painted with collodion and iodoform, a dressing of dry gauze being also secured with collodion. A little chloroform may be given, to prevent any crying and straining at the time. The child should be kept as quiet as possible afterwards, on its side, and an assistant should make sure, for the first hour at least, that no leakage is going on. Shrinking of the cyst, setting in rapidly and continuing steadily, shows that all is well. If the injection fail altogether, or only cause partial obliteration of the sac, it should be repeated at intervals of a week or ten days.*

* W. H. A. Jacobson, "Surgical Operations," Philadelphia, 1889, p. 986.

Sinclair, Robson, Evans (*N. Y. Med. Journ.*, 1888, p. 205), Hurd (*THERAPEUTIC GAZETTE*, October 1, 1889), and others have reported successful cases of excision, and more recently Bayer (*Prager Med. Woch.*, No. 20, p. 227) has reviewed the whole subject, and rejects the use of the seton, the injection of iodine, and the excision of a part of the sac, as being at the same time unsatisfactory and dangerous. He urges that the condition is one analogous to hernia, and should be treated in a somewhat similar manner; that the danger of meningitis in the one case is no greater than the danger of peritonitis in the other, and that, as compared with the operation above mentioned, it is both safer and more radical. In a child, 10 days old, in whom there was a large meningocele of the size of an apple, and who had already developed bed-sores, he performed the following operation:

The child was chloroformed, and the region of the bed-sores cleaned and rendered aseptic. Two lateral flaps were made from the skin covering the tumor, and were dissected down to its pedicle. The child was turned on its belly in order to avoid excessive loss of cerebro-spinal fluid, and the sac of the meningocele was opened. The cauda equina was seen flattened out on the posterior wall of the sac. It was loosened after dilatation of the incision, and was replaced in the spinal canal. The sac of the meningocele was then removed, leaving only two lateral flaps of the dura, which were sewed together after thorough antiseptic cleansing of the wound. The muscles and skin were afterwards brought together separately. The child recovered completely. Bayer suggests that possibly in the future, through a greater development of the technique of the operation, a bony roof over the sewed sac may be produced by forming two lateral periosteal flaps from the canal of the sacrum.

As I have had no personal experience with this procedure, and am not aware that it has been repeated by other surgeons, I have no opinion to express as to its merits, except to say that if we are to improve upon our present methods, it will be through the establishment on a sound basis of some such ideal operation.

B. In the second group of cases, which includes the various forms of tuberculosis of the spine,* our indications for operative interference may be,—1, the evacuation of pus; 2, the removal of a sequestrum or of the focus of carious bone; 3, the relief of the cord from pressure by pus, bone, or, most commonly, by the products of a simple or tuberculous external pachymeningitis.

These indications may coexist or may be quite distinct.

In considering the removal of the diseased bone, we may speak first of what Lannelongue has called “posterior vertebral disease,”—that is, cases in which the osseous lesions are localized in the transverse processes or in the laminae. Chipault quotes cases of his own and of others,†

* In relation to this, as to the surgery of the spine in general, I desire to acknowledge my indebtedness to the recent and valuable additions to the literature of this subject made by Chipault, whose careful and exhaustive review of its history (*Archives Générales de Médecine*, October, November, and December, 1890) leaves little to be done in this direction.

† Lannelongue (*Bull. Soc. Chir.*, 1878, p. 162), Boeckel (“Fragments de Chirurgie Antiseptique,” Paris, 1882, ch. v.), Polaillon (*Union Médicale*, 1883, t. i. p. 1073), Reclus (*Critique et Clinique Chirurgicales*, 1884, p. 114), Delorme (*Bull. et Mém. Soc. Chir.*, November, 1886, and *Archiv. de Méd. et de Pharmacie Militaires*, 1887, t. i. p. 51).

including one by Demoulin (*Bull. Soc. Anat.*, 1887, p. 91), in which the removal of fragments of the arches of the twelfth dorsal and first lumbar vertebræ was followed after a brief period by a marked angularity of the spine just at the point of operation, and by complete paraplegia.*

In all the other cases, seven in number, the result was perfectly satisfactory. Unfortunately, posterior vertebral disease is extremely rare. As regards disease of the bodies of the vertebræ, the most accessible region is without doubt the lumbar, and the now well-known operative procedure of Treves may be adopted as the best, with perhaps the slight modification suggested by Delorme, which consists in cutting the fibres of the quadratus lumborum on the level of each process and then abandoning the further use of cutting instruments.

The height to which we may safely ascend in attacking the laminæ of the vertebræ is a matter of much practical importance. According to Treves, the body of the twelfth dorsal vertebra is accessible, and Chipault admits that this is true provided that the finger is kept close to the spine and carried through the fibres of the psoas. If it is carried laterally he thinks that there is great danger of opening the pleura, which descends on each side below the twelfth rib, often even to the level of the transverse process of the first lumbar. As to the indications for interference, the existence of a psoas abscess, whether its vertebral origin

* Chipault does not believe, however, that the surgical intervention should be regarded as the cause of this accident.

is proved or not, is sufficient warrant for the lumbar operation, as affording the best drainage and at the same time permitting the removal of a sequestrum or the curetting of a patch of superficial caries, if they should be discovered by the finger or the probe.

Boeckel was the first to make a posterior opening for an inguinal abscess of vertebral origin, Treves has operated twice, Fraenkel once, all of them successfully. If there should be any doubt as to this form of interference in cases where the abscess points in the inguinal region, there certainly can be none when it shows itself in the loin. Cases in which, after evacuation of such an abscess, diseased bone from the vertebra has been successfully removed have been quite frequent. Delorme, Buffet, Reclus, Abbé, Saint-Germain, Tuffier, and others have done this with good results. Sometimes the artificial cavity formed in the psoas renders accessible portions of the spinal canal which could not otherwise be safely approached. Delorme has in this way been able, guided by a lumbar abscess and after removing a portion of the twelfth rib, to curette the body of the eleventh dorsal vertebra. In these cases the pleura is protected by the wall of the abscess, and is probably itself thickened by a pleuritis in the vicinity.

The success obtained in the lumbar region has led several surgeons to attempt to operate upon the bodies of dorsal vertebræ.

Boeckel, having failed to cure an abscess situated at the inferior angle of the scapula by incision, curetting, and disinfection, enlarged his incision, removed a portion of carious third rib, and curetted the lateral aspect of the bodies

of the second and third dorsal vertebræ. The patient recovered. Grünbaum did the same operation on the tenth dorsal.

Chipault believes, and, I think, correctly, that while the dorsal vertebræ are not absolutely inaccessible, and while in some cases they *may* be reached and curetted, such cases must be very exceptional, and it must be added that we have no satisfactory evidence that the vertebral bodies themselves have been attacked in such cases as the above. Where the disease is associated with caries of one or more ribs the processes are more likely to be affected, and are in all probability the portions reached by the finger and the curette of the surgeon. Dr. Agnew and I have had one such case, in which caries of the vertebral extremity of the third rib was the cause of an enormous cold abscess occupying the whole of the right scapular region, and in which we curetted the process, *not* the body of the corresponding vertebra.

Three principal objections have been made to attempts to reach the focus of bone-disease in these cases of spinal abscess:

1. It is said that operative methods practicable upon the cadáver cannot be employed in the presence of the angular deformity of Pott's disease, in which the last rib may be in actual contact with the ilium. These cases, however, are rare, and in them there is little indication for surgical interference, as the bodies of many vertebræ are deeply affected. The favorable cases are those of superficial caries, in which there is a curve of very large radius, or those in which there is disease of but a single vertebra and a very slight angular projection. In these

two classes of cases the costo-iliac space is but little reduced.

2. It is said that the solidity of the spine is affected by operation. This, of course, cannot apply to cases in which curetting is employed. It is scarcely possible that the removal of a sequestrum could materially affect the integrity of the spine; and indeed this has not occurred even after very extensive removal of portions of vertebræ.

3. Operation is said to be useless. As a matter of fact, we have now the records of fourteen operations upon the bodies of vertebræ, with eight cures, five cases improved, and one death, which had no relation to the operation itself. From these facts the following conclusions seem justifiable:*

The search for the focus of bony disease in caries of the spine is indicated with sufficient frequency to give the matter a real surgical interest. The posterior arch is accessible at all levels. The seat of disease may be sought in exceptional cases even before the appearance of an abscess, and in the presence of an abscess may be reached with great ease and certainty. The bodies of the lumbar vertebræ are accessible by Treves's operation even when no abscess which is clinically appreciable is found. If an abscess exists, even when it points anteriorly, it is proper to open it by the lumbar route and seek the focus of disease. If it points in the loin, it should, of course, be opened in that region. The lumbar incision permits us, if the abscess depends on vertebral disease, to reach, without wounding the pleura, the twelfth dorsal vertebra, and even occasionally to go above it. The eleventh dorsal is usually, in my opinion, not to be reached with safety, and, unless extensive caries of the ribs has taken place, the bodies of the other dorsal verte-

* They differ somewhat, but not materially, from those reached by Chipault.

bræ are not to be approached surgically even in the presence of an abscess.

As to the third indication in tuberculosis of the spine,—viz., the relief of cord-pressure in Pott's paralysis,—we have some encouragement to operation held out in the clinical facts:

1. That there are very many examples of the relief of paralysis in spinal caries after the pointing of a psoas or an iliac abscess, or after the evacuation of pus by the side of the spine. It is scarcely worth while to give special instances of the truth of this statement. It is familiar to all who have seen many cases of Pott's disease. Of course in such cases the evacuation of the abscess when it is accessible, or the performance of Treves's operation for the removal of the carious portion of the vertebræ, is clearly indicated.

2. That the disease of the dura mater in Pott's disease is limited to the site of the diseased vertebræ. The change from an inflammatory to a normal area is an abrupt one. Dr. George R. Elliott, in a valuable paper on the "Pressure Paralysis of Pott's Disease" (*N. Y. Medical Journal*, June 2, 1888), has fully developed this point, long ago advanced by others, in an argument to sustain the theory that this paralysis is due chiefly, almost entirely, to pressure, and not usually to grave changes in the cord itself. Some of his conclusions, sustained by autopsies in twenty-one cases, have a direct bearing upon the question and may be found subjoined.*

* It seems to him demonstrated: That we have present a simple mechanical pressure in the form of abscess products, thickened dura or bone; that the inflammatory

That these statements, at least so far as they attribute the paralysis of Pott's disease to an external pachymeningitis rather than to direct pressure from the bones themselves, are not new ones, a few quotations will demonstrate. Hippocrates, writing of spinal cases, said,—

“The palsy of the legs and arms, the wasting of the body, and the retention of urine happen chiefly in those cases where there is no spinal deformity, nor any projecting bone forward or backward; and paralytic affections take place the least frequently in cases of gibbous or angular projections.”

Mr. Percival Pott, writing in 1720 on “The Useless

process is invariably a limited one, the inflammation of the dura mater being restricted exactly to the site of the diseased vertebræ, exhibiting no tendency to extend in the membrane,—nature's medullary protection; that the medullary surface of the dura mater is almost invariably normal. It follows, then, that the pressure lesion is simply mechanical, possessing no tendency to involve the spinal cord through any inherent specific characters of the carious process—a bland mechanical lesion—and the damage it inflicts is commensurate with the pressure exerted.

Experimental physiology gives no evidence of an inflammatory lesion following experimental compression of the cord. A careful examination of the pathological findings of reported cases reveals to us, in the light of recent pathological knowledge, but few instances where we have reason to believe the original lesion to have been inflammatory. These were cases where the process was virulent, leading to a perforation of the dura mater, thus allowing the purulent products to come in direct contact with the cord, giving rise to a lepto-meningitis.

Finally, then, Dr. Elliott concludes, our researches have led to the belief that the original lesion is, as a rule, non-inflammatory, an opinion supported by pathology and experimental physiology, and corroborated by clinical manifestations.

State of the Lower Limbs in Consequence of a Curvature of the Spine," says,—

"Since I had been particularly attentive to the disorder, I thought that I had observed that neither the extent nor degree of the curve had in general produced any material difference in the symptoms, but that the smallest was, when perfectly formed, attended with the same consequences as the largest, and that the useless state of the limbs is by no means a consequence of the altered figure of the spine, or of the disposition of the bones with regard to each other, but merely of the caries."

Michaud, in 1871, completely elucidated the mechanism of this form of paralysis ("Sur la Méningite et la Myélite dans le Mal vertébral"), and Buzzard (*Transactions of the Clinical Society of London*, vol. xiii., 1880), Gowers ("Diseases of the Nervous System," 1886, vol. i. p. 169), and others have, by autopsies and carefully reported cases, confirmed these views.*

On May 9, 1883, Mr. William Macewen, in a case of complete sensory and motor paraplegia, with incontinence of urine and fæces, and of two years' duration, the result of angular curvature of the spine, removed the laminæ of the fifth, sixth, and seventh dorsal vertebræ. Between the theca and the bone he found a fibrous neoplasm one-eighth of an inch in thickness firmly attached to about two-thirds of the circumference of the membranes; this was carefully dissected off; twenty-four hours later improvement began, and in six months the patient was able to walk. In five years afterwards he was attending school and joining in all

* "Pachymeningitis, with or without suppuration, is generally due to traumatism or vertebral caries, but occasionally cases appear to arise as primary or idiopathic. In this so-called idiopathic suppuration in the spinal dura mater, trephining low down to give exit to the pus might in rare cases prove a useful procedure. Such a case is that reported by Dr. Robert Maguire (*Lancet*, July 7, 1888). Other cases have been reported by Mueller, Spencer (*Lancet*, June 14, 1879), and others." (Charles K. Mills, "Spinal Localization," *THERAPEUTIC GAZETTE*, May 15 and June 15, 1889.)

the games, including foot-ball. Mr. Macewen's cases of paraplegia in Pott's disease included four others, two of which were successful, one of them being of the most aggravated character imaginable. A third case was also successful. The two fatal cases died, one a week after the operation, the other eight months later, of general tuberculosis.

Recently Mr. Horsley has operated upon a case of complete paralysis of all four limbs from caries of the second and third cervical vertebræ, and reported the case as rapidly regaining power. The wound healed without the slightest complication.

In December, 1888, I operated upon a paraplegic patient with Pott's disease and angular curvature. The patient had grave visceral lesions, which, together with the shock of the operation, caused his death. The autopsy disclosed the existence of tubercular disease of both lungs; amyloid kidneys; a large tubercular mass undergoing softening, and connected with the bodies of most of the dorsal vertebræ and with a patch of softened lung-tissue. The cord was normal, except at the level of the eleventh dorsal vertebra, where it was soft. The dura and peri-dural tissues were normal.

Microscopical Examination of Cord.—This proved to be exceedingly interesting, especially in view of the conclusions of many surgeons and neurologists formulated by Elliott, who argue against the occurrence, or at least the frequent occurrence, of inflammation of the cord as a result of compression in Pott's disease. In the first place, the cord showed no alteration in shape, nor did there appear to be any change in the pia mater. A very striking change, however, existed in the gray matter. Here extensive hemorrhagic infiltration had taken place. It was marked on both sides, but

especially so on the left ; nor was it absolutely confined to the gray matter ; here and there the white matter had been invaded. It was of interest to note that this condition was relatively recent. The stage was still that of *red* softening, and little, if any, change had taken place

FIG. 1.



Trans-section of lumbar cord, showing hemorrhagic infarct ("Annals of Surgery"). (Drawn by Allen J. Smith.)

in the blood-corpuscles. There were no indications of long-standing and chronic inflammatory changes. In the cornua of the gray matter the nerve cells were quite well preserved ; the nerve-tubules of the white matter likewise presented a normal appearance, and there was no noticeable increase in the neuroglia. Further, it was most marked in sections made from the upper portion of the fragment,—namely, that which had undergone most compression.

I may quote my remarks published at the time the case was reported :

"The result was a surprise and great disappointment to me. So little interference with both bony and nervous

structures had occurred; the patient was so young; his general appearance was so good, and his nutrition so excellent, that my prognosis, based also on the reports of the attending physicians and neurologists, was very favorable, as regarded the immediate effects of the operation. The autopsy, of course, disclosed a condition, or rather a series of conditions, that went far both to explain the fatal result and to render it less distressing, as the case was evidently a hopeless one. Either the spinal abscess or the pulmonary tubercle would have strongly contraindicated operation had their existence been revealed by persistent fever or sweats, by cough or emaciation, or by physical signs. In the absence, however, of these, and of all other significant symptoms, and in the presence of a spinal deformity which seemed to point strongly to a pressure paraplegia, the operation seemed justifiable.

"The immediate cause of death, I am disposed to believe, was a combination of shock with the free use of ether in a patient with crippled lung-power, a degenerated heart-muscle, and amyloid kidneys. There was no hemorrhage of any moment, and indeed the quantity of ether administered was not excessive as compared with that used in every-day operations on ordinary patients.

"The chief lessons of the case are: 1. The apparently unavoidable risk due to insidious and unrecognizable complications, a risk which is probably greatly increased in tuberculous patients. 2. The existence of red softening in a case of Pott's paralysis, a condition which, if we can judge by recorded autopsies and by the expressed opinion of many competent observers, is very exceptional. 3. The necessity for extreme caution in the use of anæsthetics in all cases in which the existing and recognized disease makes coincident visceral changes probable, or even possible."

Dr. Robert Abbé, of New York, has (*Medical Record*, February 9, 1889) reported a case which he describes as an extra-dural tumor of the spine, but which seems to have been a case of caries of the dorsal vertebræ followed by localized suppuration with inflammatory thickening and desiccation of pus, rather than a tumor, causing caries by pressure. In this case the spines and

laminæ of the eighth, ninth, and tenth dorsal vertebræ were cut away by the rongeur, and the mass of dense tissue above the spine removed. The patient made a rapid recovery, regaining the ability to walk while pushing a chair. In another case of intractable brachial neuralgia the laminæ of the vertebræ from the fifth cervical to the third dorsal were removed on the right side, and the posterior roots of the sixth, seventh, and eighth cervical nerves were divided. The patient made a quick recovery.

Mr. Duncan has reported (*Edinburgh Medical Journal*, March, 1889) a case of paraplegia of nearly a year's standing, and due to Pott's disease, relieved by the removal of the spines and laminæ of the fourth, fifth, sixth, and seventh dorsal vertebræ.

Mr. W. Arbuthnot Lane reports (*British Medical Journal*, April 20, 1889) a case of Pott's disease with angular curvature in a child aged $7\frac{1}{2}$ years. The curvature was about the middle of the dorsal region. For eleven months he had been paralyzed. The spinous processes and laminæ of the fourth, fifth, and sixth dorsal vertebræ were removed with bone forceps. The body of the fifth appeared abnormally near the laminæ of the adjoining vertebræ, and the cord seemed to have been forcibly compressed between those bony points. The wound healed under two dressings. A month later he was able to move both legs freely, and at the time the case was reported seemed on the road to recovery.

The cases of Macewen give strong corroborative evidence in favor of the theory of extradural pressure rather than interstitial cord change as the cause of the paraplegia in these cases, as does that of Horsley, the cord recovering there from the effects of the pressure of the tumor, which had been exerted with sufficient firmness, and for so long a period, as almost to hemisect it. Duncan's case and Horsley's other case (of Pott's paralysis) are also valuable evidence in the same direction.

Resection of portions of the body of a vertebra has been performed in paralytic cases on the sixth and seventh cervical vertebræ by Podres (*Russkaja Med.*, No. 19, 1886), with recovery; on the dorsal vertebræ by Bocckel, with excellent results (*Schmidt's Jahrbücher*; *Phila. Med. Times*, September 8, 1883). James Israel (*Berliner Klin. Wochenschrift*, March 6, 1882) resected the arch and body of the last dorsal vertebra for caries and spinal abscess. The patient died of coincident tubercular disease on the thirty-seventh day.

Dr. John A. Wyeth has reported a case of a boy 9 years of age with Pott's disease affecting the mid-dorsal region, with paresis of the bladder and complete paraplegia of the voluntary muscles of the lower extremities. Sensation was not disturbed. A plaster jacket was applied while the patient was suspended. Four months after his admission there was no improvement. As a result of catheterization to relieve retention of urine a severe urethritis and cystitis ensued, for which supra-pubic cystotomy for drainage was done. Six months after admission, as it had been determined to explore the vertebral column, the spines and laminæ of the third, fourth, fifth, sixth, and seventh dorsal vertebræ were exposed by a median single incision, and the skin and muscles were lifted together from the bones. The laminæ of the fourth, fifth, and sixth vertebræ were divided on each side, and, with their spines, were removed. The dura was very tense immediately beneath the right lamina of the fifth vertebra, and bulged out well beyond the level of the bone which had just been removed. On opening the dura, a sharp prominence occupying the right half of the posterior portion of the cord was observed. It was about half an inch in perpendicular measurement. On puncture, a creamy substance escaped, to all appearance like thick pus. About thirty minims were evacuated, and the tumefaction was entirely relieved. The dura was closed with fine catgut sutures, and a moist aseptic dressing was applied. The patient made a good recovery, but up to five weeks after the operation there had been no improvement in the paralysis. The bladder-drainage was being continued. The fluid from the abscess con-

sisted chiefly of broken-down cord substance, with a few leucocytes. The case was evidently one of compression of the cord from Pott's disease (*New York Medical Journal*, 1890, vol. li. 1, p. 271).

Dr. Wyeth reported later that his patient was able to sit upon the side of the bed and make some steps. At the same meeting Dr. Abbé reported the case of a young adult having complete paraplegia due to a similar neoplasm compressing the cord. Three weeks after operation the patient began to walk, and was finally cured (*New York Medical Journal*, 1890, vol. li. 1, p. 271).

Mr. Henry Thompson reports a case of recent paraplegia following caries of the vertebræ at the cervico-dorsal junction. The paralysis was very extensive, extending up to the arms, and the patient was steadily deteriorating. The spines and laminæ of the last cervical and the first and second dorsal vertebræ were removed. The dura mater at first looked compressed and did not pulsate, but in a few minutes it seemed to do so. There was no appearance of any cicatricial or inflammatory tissue, but the bodies of the affected vertebræ seemed to be compressing the cord. It was not thought necessary to open the sheath, so the wound was stitched up, covered over with protective and a thick layer of boracic acid powder, and upon that a layer of alem-broth wool was placed. A small drainage-tube was inserted before the wound was sutured. For some days he was very ill, although the tympanites almost immediately began to disappear; but after he had got over the shock of the operation he gradually but steadily improved. At the time of the report he had so greatly improved that it was thought he would entirely recover (*London Lancet*, 1889, ii. pp. 315, 316).

In July, 1888, Dr. John B. Deaver operated upon a patient of Dr. Hendrie Lloyd's who had a swelling involving the left lateral region of the cervical spine, which was thought to be a tumor extending outward from the spinal canal. She had paresis of the left arm, paralysis of the left leg, exaggerated reflexes, etc. There was no paræsthesia and no anæsthesia. At the operation the laminæ of the third and fourth cervical vertebræ were cut through, but nothing abnormal in the cord or membranes was found. The cord was explored

with a needle. During the latter part of the operation the respiration altered, and continued to be gasping and irregular at intervals until her death, three days later. At the autopsy there was found an old extravasation of blood, with advanced degeneration, a short distance below the decussation of the pyramidal tracts. Death was thought to be due to phrenic inhibition the result of the exploration (*Amer. Journ. of the Med. Sci.*, December, 1888, p. 564).

Mr. G. A. Wright reports a case of a child 7 years of age with Pott's paralysis. The angular curvature was most marked in the mid-dorsal region. An incision about four inches in length was made along the line of the most prominent spinous processes, and the soft parts on each side were separated so as to expose the osseous surfaces. Three laminæ were divided on each side, and were removed with their attached spines, uncovering the theca of the spinal cord, which, at the lower part exposed, was found surrounded by a buff-colored, tough, leathery substance; this was cut away with scissors. The cord did not appear to pulsate, but no point of constriction could be found. The muscles were brought together by deep sutures of catgut, and the skin with waxed silk; a small drainage-tube was left in. The wound, having been dusted with iodoform and boracic acid in equal parts, was dressed with sublimated wool wadding. Careful antiseptic precautions were observed before and during the operation. The trunk was supported by a special iron splint. The wound healed rapidly by first intention, except at the drainage-opening, which, however, also quickly closed; very slight improvement was soon followed by relapses (*Lancet*, 1888, ii. pp. 64-66).

M. Buffet reports a case of tuberculous ostitis of the lumbar vertebræ in which he divided the articular processes and the sides of the bodies,—effecting a permanent cure (*Gazette des Hôpitaux*, December 2, 1886).

William Thorburn reports a case of operation for paralysis of Pott's disease in a child 6 years of age. Chloroform having been given, a vertical incision, about three inches long, was made in the middle line, over the affected spinous processes; the soft parts were raised

from the bones by a raspatory, and the laminæ of the third dorsal vertebra cut through by a Hey's saw and bone-forceps. An opening about the size of a sixpence was thus made in the spinal canal, and about fifteen minims of pus at once escaped. At the bottom of the opening was seen the apparently healthy dura mater. A drainage-tube was then inserted, so bent that its convexity lay in the opening into the spinal canal, and the wound was sutured. The spray was used, with carbolized dressings.

After the operation the breathing was distinctly better, but no other change could be observed. On the following morning the improvement appeared to be maintained, but there was a good deal of pus in the urine. The wound being dressed, no more pus escaped. On the afternoon of this day breathing again became much worse; the temperature, which had fallen to normal, rose to 104.6° , and shortly after midnight the boy died asphyxiated. No post-mortem examination was permitted (*British Medical Journal*, 1888, ii. pp. 665, 666).

Eugene Boeckel reports a case of a woman 43 years of age, in whom an abscess formed beneath the angle of the left scapula, which, after operation, left a fistulous tract some inches in length, and extending upward. This was finally found to lead to the lateral aspect of the bodies of the second and third dorsal vertebræ, which were roughened and carious. These were curetted, drainage-tubes were employed, and at the time the case was reported the patient appeared to be on the road to recovery. Boeckel thinks that in cases of cold abscess connected with the spine we should be content with simple evacuation, but if through the incision we can reach the body of the carious vertebra, it is proper to employ the curette, so as to prepare it for the application of iodoform and antiseptic dressings (*Gazette Hebdomadaire*, 1882, 2d series, vol. xix. p. 171).

Dr. Banham and Mr. Arthur Jackson report the case of a healthy-looking boy, aged 12, who had been completely paraplegic for nine months previous to operation. There was no tubercular history in the family. There was a prominence on the back corresponding to the lower dorsal region. There was much diminution of sensibility. His feet were blue and cold. His legs were drawn up in a state of tonic contraction. He had no

control over his sphincters, and there was an exaggerated tendon reflex on both sides, with ankle-clonus. An incision three inches and a half long was made over the lower dorsal spines. The laminæ and spinous process of a vertebra (the ninth) were removed, and the dura mater laid bare, but not opened. No pus was found, but the spinal cord rose to the opening made in the bone. The day after the operation the temperature rose to 102° F., but fell during the next two days to 100° F., where it remained for three weeks, with slight nocturnal elevations; after that it was normal. The wound was dressed for the first time on December 26, twelve days after the operation, and the sutures were removed. On January 10, fifteen days after the last dressing, the wound was again examined, and was found healed. A week after the operation the boy was able, for the first time since his admission, to micturate properly, and when he desired; he had control over his sphincters, for which result alone the operation had been of great value. The painful tonic contraction of his leg- and thigh-muscles had quite disappeared, and he was able to draw his knees up against his abdomen, and slightly move his toes. Faradic contractility was, however, much diminished, though sensibility remained. He could distinguish with accuracy the point pricked with a pin at any part over each leg. His sensations also to touch, pressure, and temperature were normal (*British Medical Journal*, 1883, i. p. 812).

Drs. Bullard and Burrell report the case of a man with paraplegia, bed-sores, girdle-pains, etc., and with a distinct prominence involving the fourth, fifth, and sixth dorsal vertebræ. His condition dated back about seven months. Resection of the third, fourth, fifth, and sixth dorsal vertebræ was accomplished, the spines and laminæ of these vertebræ being turned up, hinging at a divided point of the spine of the second dorsal vertebra. The patient died from shock in thirty-six hours (*Trans. Am. Orthopaedic Association*, vol. ii. p. 247).

Jackson (*British Medical Journal*, April 28, 1883, p. 812) removed the laminæ and spinous process of the ninth dorsal vertebra in a case of Pott's paralysis in a child 12 years of age. There was marked improvement afterwards in both motion and sensation. Southam

(*British Medical Journal*, September 22, 1888, ii. p. 665) operated on a child 6 years of age, and removed the laminæ and the spine of the third dorsal vertebra. A few drops of pus escaped from the canal, and the dura mater appeared thickened. The child died the same evening. Demons (*Bull. Soc. Anat. et Phys.*, Bordeaux, 1888, lix. p. 288), in a man 35 years of age, with complete paraplegia, removed the spines and laminæ of the third, fourth, and fifth dorsal vertebræ. Temporary improvement was followed by death one month later. At the autopsy it was found that the cord was compressed to a much greater extent than had been seen at the time of operation. W. A. Lane (*Lancet*, July 5, 1890, ii. p. 11) reports a case of a man 32 years of age, with dorsal angular curvature and rapidly-developing paraplegia. The spinous processes and laminæ of the ninth, tenth, and eleventh dorsal vertebræ were removed. A mass of granulation-tissue intermingled with pus projected from the canal. This was removed, as well as a slight prolongation which extended to the right and in front of the dura mater. There was complete return of both motion and sensation.

Kraske has reported (*Chipault, loc. supra cit.*) four cases in which he has operated for Pott's paralysis. In all of them there were growths consisting largely of granulation-tissue, and more or less adherent to the dura mater, which were removed by forceps and scissors. In three cases this tissue was infiltrated with pus. In the fourth case it enclosed an abscess containing about two teaspoonfuls of pus, and several sequestra were present. In one case there was no improvement. The patient died eight weeks later from the progress of the disease. Extensive pachymeningitis was found reaching beyond the area of operation. In the others the results were as follows: In one, a man 57 years of age, there was caries of the fifth dorsal arch. The third, fourth, fifth, and sixth arches were resected. Sensibility returned in the limbs that afternoon, motion three or four days later. In one month the patient left his bed and tried to walk; in two months the paraplegia returned, and five months later the patient died of pulmonary tuberculosis. The autopsy showed that the caries had extended to the body of the fifth dorsal vertebra. There was no deformity at

the level of the operation, and at that point the lesions of pachymeningitis were completely cured. In another case, a patient 14 years of age, complete paraplegia, with vesical paresis, was present. The arches of the fifth and sixth dorsal vertebræ were resected. Some hours afterwards motion of the limbs occurred, but two months later the paraplegia returned. At the time of report the patient was still living, but unimproved. In the last case, a boy 12 years of age, with complete motor and sensory paralysis and vesical paresis, the arches of the eighth, ninth, and tenth dorsal vertebræ were resected. Eight days afterwards motion began in the limbs, the bladder acted normally. One month later, however, he became worse, and five months later there was slight motion of the limbs, but he was otherwise unimproved.

Gerster (*Medical Record*, July 26, 1890, p. 131) reports the case of a boy 15 years of age, with paraplegia from Pott's disease. The laminæ of the sixth and seventh dorsal vertebræ were raised and an extensive abscess evacuated. Caseous masses were found encircling the motor and sensory roots on both sides, the transverse processes of the sixth, seventh, and eighth dorsal vertebræ on the right and of the fifth, sixth, and seventh on the left were carious, and the corresponding costo-vertebral articulations were destroyed. All these diseased parts were raised and the bodies of the sixth and seventh dorsal vertebræ curetted. Seven months later the patient was completely cured.

Horsley reported six cases of trephining in Pott's disease at the International Congress in Berlin in 1890: 1. A man, 62 years of age, complete paraplegia for twenty months; trephining; a little suppuration noticed; death from compression; a large abscess found. 2. A woman, 23 years of age; paraplegia for five years; after operation slight improvement in motion and sensation. 3. A boy, 16 years of age; paraplegic for eighteen months; abscess of bone found; union by first intention; slight improvement. 4. A boy, 17 years of age; paraplegic for eight months; union by first intention; very slow improvement in motion. 5. A girl, 15 years of age; paraplegic for one year; bony abscess found; union by first intention; return of sensation in ten days; gradual return of motion; could walk in one month. 6. A boy

16 years of age; paraplegia; weakness of the left arm dating for three years; union by first intention; patient *in statu quo*.

Chipault (*op. cit.*) reports two cases: One a boy, 9 years of age; complete paraplegia; removal of the fifth, sixth, seventh, and eighth dorsal arches; slight improvement, followed by return of paraplegia. Second case, a boy, 9 years of age; case of fracture occurring during Pott's disease, and followed by sudden paraplegia; resection of the fourth, fifth, sixth, seventh, and eighth dorsal arches; marked improvement in motion, but death from pulmonary disease in three weeks. At the autopsy compression of the cord by a portion of the body of the eighth dorsal, and extensive pachymeningitis were found; death occurred from generalized caseous broncho-pneumonia.*

The analysis of forty cases of this operation for Pott's paralysis, which are all I have been able to bring together, reveals the following facts. In twenty-two there was either improvement or absolute cure. The unsuccessful cases which recovered from the operation were in some instances the subject of secondary disease. Wright's case improved for a month, and three of those of Kraske did likewise, and then relapsed. In the case of Demons, and in one of those of Kraske, the result was absolutely negative. This was due, as the reports show, to insufficient removal of the compressing cause. The deaths were twelve in number,

* Selecting from the thirty-five cases collected by Chipault those in which all the details as to the number of arches raised were given, they were as follows: One arch in two (Southam, Jackson); two arches in three (Horsley, Deaver, Kraske); three arches in twelve (Macewen, Lane (2), Wyeth, Wright, Abbé, White, Thompson, Demons, Kraske (3); four arches in two (Buzzard, Duncan); five arches in one (White); unknown in six (Macewen (4), Abbé, Coleman).

showing a mortality of thirty per cent., and were due to various causes: in my own case, to shock and extensive renal and pulmonary disease; in the case of Deaver and Lloyd, either to the anæsthetic or, as they supposed, to wounding of the medullary centre of the phrenic during the operation; in the cases of Macewen and Coleman and of Chipault, to pulmonary tuberculosis; in the case of Burrell, probably to shock. In the others death was directly due to the gravity of the disease of the cord.*

In coming to a conclusion as to the indications for operative interference in Pott's paralysis, the age of the patient is of great importance, the proportion of cures and of improvements being much greater in children and in adolescents than in adults. Among the twelve fatal cases the age was given in nine, and there were two children and seven adults. Among three cases in which no improvement followed operation: children,—Wright, 7 years; Kraske, 14 years; Hardy, 16 years.

Among twenty-two cases of improvement or cure there were fifteen children and four adults, the age of three being unknown.

While surgical interference is thus shown to be much better borne by children than by adults in Pott's disease, as in most other conditions, we must remember also the well-known clinical fact that the disease itself in children is far less grave and threatening than in adults.

* Chipault agrees in a general way with the opinions of Kraske, Bullard and Burrell, and Thorburn, and believes that we should not operate except where we have grave medullary symptoms on the one hand and a fairly good general condition on the other.

The seat and extent of the osseous lesion are also important, the prognosis being unfavorable in direct proportion to the height of the caries, above all when respiratory complications exist previous to the operation. All the patients who died had an upper dorsal or a cervical lesion except my own, in which case the equally fatal condition of tuberculosis of a large number of vertebral bodies existed.

The effect of suspension in the treatment of Pott's paralysis has been so favorable in a number of cases that it should occupy a prominent position in the consideration of our therapeutic resources, and should always be tried, or, at least, carefully discussed, before operative measures are thought of.

Weir Mitchell (*Amer. Journal of the Med. Sciences*, May, 1889), has, it appears to me, shown conclusively: That suspension should be used early in Pott's disease; that used with care it enables us slowly to lessen the curve; that in these cases there must be in some form a replacement of the crumbled tissues; that no case of Pott's paralysis ought to be considered desperate without its trial; that suspension has succeeded after failures of other accepted methods; that the pull probably acts more or less directly on the cord itself, and that the gain is not explicable merely by obvious effects on the bony curve;* that the methods of extension to be used in these cases may be very various, only provided we do get active extension; that the plan and the length of time of extension must be made to conform to the needs, endurance, and sensation of the individual cases.

* Dr. G. F. Lydston suggests ("Addresses and Essays," Chicago, 1891) that the elongation of the spinal canal produces a vacuum, which causes an increased vascular supply to the cord with a corresponding increase in its nutrition.

I desire merely to express my concurrence with these views, and shall not further pursue this branch of the subject.

The evidence at present available in relation to the operative treatment of spinal tuberculosis with symptoms of pressure upon the cord appears to me to justify the following conclusions:

1. The paralysis in Pott's disease is not, as a rule, due to a transverse myelitis or a hopeless degeneration, and is not usually due to the pressure of the carious or displaced vertebræ, but is, in the majority of cases, the result of an external pachymeningitis, which results in the formation of an extra-dural connective-tissue tumor.

2. Speaking generally, a favorable prognosis is to be given, especially in children, in cases of Pott's paralysis in which the abscess, if any exists, can be evacuated; the treatment by extension and with a plaster jacket can be employed, and the patient can be put under the most favorable hygienic conditions.

3. In cases in which all this has been tried unsuccessfully, or in those in which the disease is slowly but steadily progressing to an unfavorable termination; when with more or less complete loss of motion and sensation below the level of the lesion there are incontinence of urine and fæces and the development of bed-sores, and especially when acute symptoms threaten life, resection becomes entirely justifiable.

4. Operation having been decided upon for any or all of the above reasons, the prognosis will be favorable in direct proportion to the youth and strength of the patient, the absence

of generalized tuberculosis, and the nearness of the lesion to the base of the spine.

5. When the tuberculous process affects the arches and there is paraplegia, we may sometimes operate, hoping not only to free the cord, but to remove at the same time the focus of disease. This double indication may also be fulfilled in those cases where, without bony disease, there is posterior pachymeningitis or a tuberculoma occupying the canal. Here again, however, time and careful attention to hygiene, including change to sea- or mountain-air, often work wonders.

6. If the lesion of the bodies of the vertebræ is in the lumbar region at a point where these bodies are accessible, it might be possible in certain cases to expose the cord from the back, by removal of the laminæ, with the object not only of removing pressure but of reaching and taking away the diseased bone and tubercular granulation.

7. In tuberculosis of the body of a vertebra and compression of the cord by anterior pachymeningitis we can fulfil only one indication,—liberate the cord from pressure. We should operate only in grave cases where acute compression, the appearance of respiratory complications, the rapid development of degenerative processes, force us to interfere, or where the course of a chronic case is steadily towards a fatal termination although no advanced visceral tuberculous lesions are present.*

C. Passing now to the third group of cases, and taking up the surgery of the neoplasms of the cord unassociated with traumatism

* Chipault, *op. cit.*

or caries, we may very briefly review the history.

In fifty cases of spinal tumor tabulated by Drs. Mills and Lloyd, and among fifty cases tabulated by Horsley, the two including practically all those of which we have any satisfactory knowledge from the surgical and pathological stand-points, no mention is made of operation in a single instance.

In 1882, Mr. Byron Bramwell, of Edinburgh, in his work on "Diseases of the Spinal Cord," made the following important suggestion in regard to this subject:

"The removal of extra-medullary tumors is not yet a recognized plan of treatment. This is partly owing to the uncertainty of diagnosis, and partly to the serious nature of the operation. The difficulties in diagnosis are disappearing, and, thanks to antiseptic surgery, we can now conduct operations which were formerly unjustifiable. I would advise an operation in any case in which the symptoms were original, in which the diagnosis clearly indicated the presence of a tumor, in which there was no evidence of malignant disease, in which the exact position of the growth could be localized, and in which a vigorous anti-syphilitic treatment had failed to produce beneficial results."

Other neurologists, notably Mr. Gowers, expressed the same general views; but the strong prejudice existing among surgeons against the operation of resection, and the uncertainty of diagnosis on the part of the neurologists, combined to prevent operative interference in such cases, patient after patient perishing without even an attempt at treatment.

In June, 1887, Mr. Victor Horsley operated upon a case, the symptoms of which had begun immediately after a severe traumatism in 1884, and were thought to

indicate an intercostal neuralgia, localized beneath the lower part of the left scapula. For a long while the pain was the only marked symptom, but in February and March, 1887, there came on distinct loss of power in both legs, and by June the symptoms were those characteristic of a transverse lesion of the cord a little above the middle of the dorsal region.

Mr. Horsley operated very much after the method employed many years previously by Gordon, McDonnell, Hutchison, and others, trephining the laminæ of the fifth vertebra after having first cut off the fourth, fifth, and sixth dorsal spines. After the removal of the trephine button, the rest of the laminæ of the fourth, fifth, and sixth vertebræ were then taken out by means of the bone-forceps and knife. The dura was opened, but nothing abnormal was discovered. The third and seventh laminæ were then removed, and finally the lamina of the second dorsal vertebra, disclosing an oval or almond-shaped tumor, which subsequently proved to be a fibro-myxoma. This was easily removed, when the lateral column on that side was found to be so notched by pressure that the bottom of the groove nearly reached to the middle of the cord. The patient made an excellent and fairly rapid recovery, and one year later was able to do a day's work of sixteen hours, including much standing and walking about.

In October, 1888, I operated on a case of paraplegia thought to be due to focal spinal lesion, possibly to a tumor, in a patient of Dr. F. X. Dercum's. The case will be found reported very fully in the *Annals of Surgery* for June, 1888. Although no tumor was found, the removal of peri-dural connective tissue which had undergone some thickening, and the separation of subdural adhesions were followed by very marked improvement in sensation and mobility, which improvement has gone on to entire recovery.

On December 25, 1887, he was attacked with severe pains in the arms and shoulders, burning and shooting in character and attended by pain on motion, but no loss of power. He described it as rheumatism.

Three or four days later, however, he noticed distinct weakness of the thighs. This weakness increased and spread rapidly down the legs to the feet, and upward

over the trunk as far as the breast, and, in the course of eight days, had deepened into absolute paralysis of the parts involved, including both sphincters. At the same time the paralyzed parts became the seat of profound anæsthesia. The latter extended up to the level of the nipples, at which point an intense girdle-pain made its appearance. A bed-sore, trophic in character, followed in time, and added to the patient's sufferings. All the reflexes of the legs, both deep and superficial, became exaggerated. Percussion of the spine elicited pain over the third and fourth vertebræ and to a less extent over the fifth. Flexion and torsion of the trunk also gave rise to pain in this region, while slight blows upon the head in the direction of the spinal axis gave rise to frightful exacerbations of the girdle-pain.

For upwards of ten months this man's condition had grown gradually worse, until the full development of his symptoms, as detailed, had been reached. His general health had suffered severely, and certainly the prospect of recovery was anything but hopeful. Internal therapeutics had been exhausted, and, after a consultation of the neurological staff, it was decided to trephine the spine. The operation was regarded as exploratory in character, though the symptoms pointed directly to a localized affection of the spine or of its immediate contents.

The fifth, fourth, third, second, and first dorsal spines and laminae were successively removed, and the exposed dura, which seemed unusually thickened and resistant, was incised and opened for a distance corresponding to the length of the wound. The dura was found to be very adherent to the subjacent pia mater by numerous fine bands of new connective tissue, especially in the upper angle of the wound. These adhesions were separated with some little difficulty. The cord was then cautiously explored with the finger, but nothing further was found. The subsequent surgical progress of the case was all that could be desired.

A few hours after the operation, the effect of the anæsthetic having entirely passed off, the patient stated that the girdle-pain had entirely disappeared; nor did it at any subsequent time return. On the following day there was distinct though very slight return of sensation in the feet, and this steadily increased day by day.



FIG. 2.—POSTERIOR VIEW OF PATIENT, SHOWING CICATRIX. ("Annals of Surgery.")



FIG. 3.—LATERAL VIEW OF PATIENT, SHOWING ATTITUDE AND GAIT. ("Annals of Surgery.")

Errors of location as regarded the level of the impression, and allocheiria, were present and quite persistent. On the sixth day a barely discernible voluntary movement of the toes of the right foot was observed. Little by little a return of voluntary motion obtained, until some two months later, when he could distinctly move the feet and the muscles of the thighs. Sensation, too, steadily improved, allocheiria disappearing, a few errors of location being made. In addition the bed-sore had promptly healed, and some slight control had been regained over the sphincters. This was the patient's condition up to April, 1889. The operation had been performed October 17, 1888.

During the months of May and June the gradual and gratifying return of spinal functions continued, and by July very good control of the urinary sphincter had been regained. He was now capable also of extending and flexing the legs and thighs at will, and a little later he insisted on being raised to the sitting posture. About this time also his control over the bowel became more decided. His improvement continued unabated until the latter part of August, when he had the temerity to attempt a few steps out of bed. He was, however, restrained in his efforts in this direction for some time longer, and his ambition limited to sitting up in a rolling-chair. In getting in and out of bed, however, he showed such a decided return of power that limited efforts at walking were soon permitted. His progress now was relatively rapid, and he soon learned to walk the entire length of the ward with the aid of a cane. At present he has completely recovered, and is now out of the hospital, earning his living by manual labor. (See Figs. 2 and 3.)

The technique of Horsley as to his successful case of spinal tumor has been followed in three other cases, once with success by Pescarole, who removed a subdural tumor compressing the cord from the second to the fifth dorsal vertebræ. In the other two cases, one, also of Horsley's, died of shock. Sonnenburg operated for a rapidly-developing sarcoma, which could not be completely removed. Death occurred in six weeks. Five other cases of trephining for tumor are as follows:*

* Chipault, *op. cit.*

Reydellet ("Dictionnaire des Sciences Médicales," vol. xxxiii. p. 564, 1819) exposed the cord by accident during the removal of a hydatid cyst. The patient died a year later, as a result of suppuration developed in the cyst. Athol Johnson (*Trans. Path. Soc.*, London, 1856-57, vol. viii. p. 16) removed from a child of ten months a congenital tumor, which proved to be a lipoma. It was at the level of the first sacral vertebra. A portion of the tumor was found later to be within the dura. This was not touched. The patient died in six weeks, of peritonitis. Wright (Thorburn, *op. cit.*) removed a portion of a fibro-sarcoma of the neck involving the brachial plexus and invading the spinal canal. The tumor lay external to the canal, but appeared to communicate with it by a diverticulum penetrating the third intervertebral foramen. The tumor was removed, but the operator merely curetted this tract. There was some improvement. Bardeleben (*Berlin. Klin. Woch.*, Nov. 4 and 18, 1889, Nos. 44 and 46, pp. 946 and 1004) removed a tumor adherent to the seventh and eighth ribs and to the vertebral arches, between which it penetrated. This portion appears to have been left undisturbed. Death occurred in a few hours, and at the autopsy a nodule was found lying upon the posterior portion of the dura mater and compressing the cord. Abbé has reported (*N. Y. Med. Record*, 1890, vol. xxxviii. pp. 85-92) a case of pressure paralysis from extra-dural sarcoma. The operation was performed after the symptoms had existed for eight months. He resected the arches of the eighth, ninth, and tenth dorsal vertebræ and completely removed the tumor. The patient died on the ninth day.

A sixth case, reported in the *Neurolog. Centralblatt*, by Laquer, was operated on by Rehan on account of loss of sensation in the lower extremities, abolition of the patellæ reflexes, continuous and severe sacral pain, etc. A small extra-dural lymphangioma was found, compressing the cauda equina. It was easily removed. Two weeks later all pain had disappeared, and four months afterwards recovery was almost complete (*Med. and Surg. Reporter*, September 12, 1891).

Five cases of intraspinal section of the posterior roots of the spinal nerves for obstinate neuralgia have

been reported. 1. Those of Abbé are summarized as follows: *a.* Intractable brachial neuralgia, nerve-stretching, amputation, and finally intra-dural division of the sixth, seventh, and eighth cervical nerves; no permanent recovery. *b.* Intractable brachial neuralgia; intra-dural division of the posterior roots of the sixth, seventh, and eighth cervical and first dorsal nerves; recovery; improvement (*Medical Record*, 1890, vol. xxxviii. 2, pp. 85-92). 2. Bennett reported (*Lancet*, April 27, 1889, i. p. 839) a case in which he had divided close to the cord the posterior roots of the first, third, fourth, and fifth lumbar pairs and first and second sacral nerves. The spasms from which the patient suffered continued, but the violent neuralgic pains disappeared. The man died in fifteen days, of cerebral hemorrhage. 3. Horsley has reported two analogous cases in the tract of the eighth and ninth dorsal nerves. The posterior roots of these two nerves were divided. There was slight improvement, but later involvement of other nerves. The second case was a boy 15 years of age. He suffered from violent pains, vaso-motor troubles, and atrophy in the region supplied by the nerves coming from the left path of the lower third of the cervical enlargement of the cord. The seventh and eighth posterior roots were divided on the left side. Cerebro-spinal fluid escaped for three weeks. There was considerable improvement. Chipault suggests that such operations as the foregoing can only be applicable to cases of exceptional gravity. In such cases their advantages are,—1, to limit with certainty the route of an ascending neuritis; 2, in cases of difficult diagnosis to permit of the exploration of the vertebral canal; and, 3, to limit the section to the posterior nerves, thus avoiding paralysis of the territory innervated by the anterior nerves.

We may now consider the possible indications for operation in this third group of cases, or those in which there is reasonable ground for suspecting the existence of a removable neoplasm. Naturally, this group will, more than any other, try the diagnostic powers of both surgeon and neurologist, and no broad

view of the subject can be taken without a brief enumeration of the various sources of error. This will lead me upon ground properly belonging to the neurologist, but I may perhaps be pardoned if I give a brief outline of the general diagnostic points which it will be necessary to bear in mind before deciding upon or rejecting operative interference. In the first place, it will be requisite to determine whether the symptoms are due to pressure on the cord or to inflammatory or other changes involving primarily the structure of the cord itself. If, in a case of paraplegia, we have the history of a very gradual onset, beginning with pain and followed first by motor paralysis and then by sensory paralysis; the symptoms being irregularly unilateral; the pain having first seemed to be neuralgic or rheumatic and burning and shooting in character; if the pain and anæsthesia in the lower limbs ascend gradually from the soles of the feet towards the trunk; and if at the same time there is a constant dull ache in a distinct segment of the spinal column, accompanied by a feeling of weakness at that point, much heightened by fatigue, we have a group of symptoms pointing strongly in the direction of a neoplasm. In addition, it would be found that at first the reflexes, both deep and superficial, were much exaggerated, becoming gradually lost as destruction of the cord with descending degeneration and wasting grew more marked, the abolition of the reflexes beginning, as in the case of the pain and anæsthesia, in the plantar region and passing gradually upward.

Later in the disease we have the development of spasms with clonus, most marked in

the intra-dural cases. The same remark is true of the symptom of rigidity. Local nutrition is not usually impaired; tenderness of the spine on percussion when it occurs in the dorsal region appears to be lower than the tumor producing it; in the cervical region, according to Horsley, this generalization does not seem to hold so closely. The feelings of stiffness and weakness will usually be found to correspond to the position of the tumor. Lateral curvature of the spine is a secondary result of the tonic spasm of the spinous muscles, and therefore the concavity of the bend is on the same side as the growth. The pupils are not affected, except when the cord is pressed upon above the level of the second dorsal nerve.

The age of the patient, judging from Mr. Horsley's tables, throws but little light upon the diagnosis of tumor, as we find lipomata occurring at an average age of $2\frac{1}{2}$ years, sarcomata at 18 years, echinococcus at 34 years, tubercle at 39 years, scirrhus and myxoma at 48 and 53 years. These figures apply to extra-dural growths. In the case of intra-dural growths we have tubercle at $18\frac{1}{2}$ years, myxoma at 43 years, fibroma at 44 years, sarcoma at 41 years, psammoma at 51 years. It will be seen, therefore, that while age may be of use in eliminating certain forms of growth, as, for example, tubercle in intra-dural growths in persons beyond 30 years, it is of little value in deciding the general question as to the presence or the absence of a neoplasm.

This sketch of the principal symptoms makes a tolerably distinct clinical picture, but one which is, nevertheless, liable to great variation,

and therefore difficult to differentiate from that of certain conditions of the cord, some of which are due to causes quite beyond the reach of operation.

The chief of these, with the most obvious diagnostic points, are as follows :

Spinal Hemorrhage: Intra-medullary.—Onset sudden; history of traumatism, or of disease associated with profound blood-changes; symptoms bilateral; pain in back; rapid disappearance of reflexes connected with the affected segment; spasms and rigidity and paralysis appear rapidly; girdle symptom; bed-sores; incontinence of fæces; retention of urine very early in case; rapid course; often fatal.

Extra-medullary.—Pains in limbs, spasms, etc., more marked; paralysis supervenes more slowly; course of case much slower and much more favorable.*

* “ The diagnostic symptoms of meningeal hemorrhage, as given by Gowers and others, and according to my own experience, are as follows: 1, sudden and violent pain in the back, less or more diffused; 2, pain along the course of the nerves passing through the membrane near the extravasation; 3, abnormal sensations,—tingling, etc., and hyperæsthesia,—referred to the same parts; 4, spasm involving vertebral and other muscles supplied by affected nerves, and also sometimes the muscles supplied by the cord below the seat of the hemorrhage; 5, sometimes general convulsive movements; 6, sometimes spasmodic retention of the urine; 7, consecutive paralytic symptoms, but not usually complete paralysis.

“ Some points of differential diagnosis between meningeal hemorrhage and extravasation into the substance of the cord should be borne in mind. Symptoms of irritation, such as pain, hyperæsthesia, paræsthesia, and spasm, in meningeal hemorrhage, are usually immediate or very early, and may precede paralysis, which is commonly not complete. In hemorrhage into the substance of the cord, paralysis may be very complete at first, or rapidly become so, and symptoms of irritation may be

Pachymeningitis Externa, from Caries.—Common cause, caries of vertebræ; family history of phthisis, scrofula, or tubercle; personal history fair; patient weak and feeble; usually history of injury also; onset slow; first symptoms often rigidity of spine, with tenderness on pressure or on tapping top of cranium, or on flexion or rotation; muscular palpitation and weakness rather than spasms or paralysis; irregular hectic fever; characteris-

very largely wanting. Hemorrhage may, and not infrequently does, involve not only the membranes but also the substances of the cord, giving complex symptoms" (Chas. K. Mills, "Spinal Localization," THERAPEUTIC GAZETTE, May 15 and June 15, 1889).

"In some cases of intraspinal hemorrhage, whether primary or secondary, trephining might be performed in two places in order to make sure of a good result,—namely, at the supposed seat of the extravasation, and the lowest portion of the lumbar spine, where, as already indicated, much of the extravasated blood would gravitate. Kronlein, it will be remembered, has recommended that in cases of cranial meningeal hemorrhage two trephinings should be performed if one is not successful, and several cases of failure in trephining for intracranial hemorrhage have been reported which would have been successful had the second operation been performed. In like manner two trephinings of the spine, or a single trephining at the lowest possible place in the lumbar region, might prove successful where failure would otherwise result.

"The somewhat frequent occurrence of spinal hemorrhage with fracture of either body, spines, or laminæ of the vertebra must not be overlooked. The diagnosis of the exact height of the lesion and the decision as to trephining may often have to be settled negatively or positively through a consideration of the question of the probability of a double lesion in cases of accident,—namely, both fracture and hemorrhage. The fracture and the hemorrhage may be situated at different levels, or, if the hemorrhage occurs primarily at the seat of the fracture, it may find its way down the canal" (Chas. K. Mills, "Spinal Localization," THERAPEUTIC GAZETTE, May 15 and June 15, 1889).

tic deformity; spinal abscess; bladder and rectum rarely affected; emaciation.

Chronic Transverse Myelitis.—Frequently a history of acute myelitis; slow in onset; bilateral; first symptom apt to be an impairment of motion, ranging from paresis to absolute paralysis; increased reflexes; ankle-clonus; rigidity common, but paresis, contractions, etc., more marked than paralysis; pain in back and girdle symptom common; anæsthesia and paræsthesia proportionate to motor paralysis; bladder and rectum not greatly involved; slow course.

Primary Lateral Sclerosis, or Spastic Paraplegia.—Often attacks robust adults between 30 and 50; slow in its onset; bilateral; begins with a feeling of weight and weakness in lower limbs, preceded by a peculiar and characteristic gait; spasm chiefly of muscles of lower extremities; manipulation of those limbs throws them into tonic spasm; paralysis not very common early; paresis and rigidity are characteristic symptoms, together with arched spine during peculiar locomotion.

Hypertrophic Cervical Meningitis.—Symptoms affect chiefly the upper limbs, with upper part of spine and thorax; bilateral; marked pain and rigidity, involving all these regions; paralysis occurs in second stage, and affects first and chiefly arms, shoulders, etc.; no atrophy of lower extremities; no bed-sores; no bladder or rectal trouble.

Having decided in any given case that the symptoms are probably due to tumor, the interesting question whether it is intra-medullary or extra-medullary will still remain to be settled. The best general guide will be found in the fact that the symptoms of intra-medullary growths are chiefly those of motor and sensory impairment, while the extra-medullary growths produce much more markedly irritative symptoms, as, for example, pain, spasms, etc. In the presence of a paralysis of gradual development, preceded by long-continued signs of nerve-irritation, and with a distinct uni-

lateral element, the transference of paralysis from one to the other limb having been effected slowly and after a considerable interval, the diagnosis of compression of the cord by some cause outside of its own structure would seem warranted. Aneurism might be excluded in the absence of the characteristic physical signs and of evidence of erosion of the spinal column; gumma would be accompanied by a history of syphilis, would often be associated with other and recognizable specific lesions, and would possibly yield to the use of iodide of potassium; a growth (cancer or tubercle) of the bodies of the vertebræ themselves usually causes a perceptible deformity. By attention to the points which I have mentioned, a reasonably correct opinion may be arrived at, but I would strongly advise that in no case should the surgeon undertake a spinal resection based on a diagnosis of tumor without having called to his aid a skilled neurologist and carefully studied the case with him. The same remark applies with even more force to the question of localization. The broad general principles long applied in cases of traumatism are of course equally applicable to tumors, but there are numerous refinements of modern diagnosis which belong especially to the province of the neurologist and which are of vital importance in selecting the site of operation in cases of supposed tumor. Horsley's experience in the patient of Dr. Gowers is ample evidence of the unavoidable uncertainty as regards the particular vertebra or vertebræ to be attacked, but there is every prospect that these diagnoses will become more and more scientifically exact in the near future. In the mean while I would

refer the surgeon who desires carefully to study for himself this side of his cases to the articles referred to below.*

Having decided that the probability is in favor of the existence of a tumor, and having also fixed upon its probable seat, the surgeon is confronted with the important question of the advisability of operation; in other words, with the question of prognosis.

All the evidence which we now have points to extraordinary reparative power on the part of a cord which has simply been suffering from compression, and to an almost equally remarkable tolerance of operative interference. The material for finely-differentiated prognoses can hardly yet be said to exist, but in a general way it is safe to say that the diagnosis of tumor (if it be non-malignant) carries with it a reasonably favorable prognosis, which is strengthened if, in addition, the tumor is thought to be extra-medullary.

As a result of the above considerations it seems to me proper to conclude that every

* Seguin, "Localization of Spinal Lesions" ("Pepper's System of Medicine," vol. v. p. 77); Starr, "Localization of Functions of the Spinal Cord" (*American Journal of Neurology and Psychology*, vol. iii., 1889); Gowers, "Diseases of the Nervous System," vol. i. p. 142; Thorburn, *The Medical Chronicle*, April, 1889, p. 1, and the *British Medical Journal*, December 22, 1888; "A Contribution to the Surgery of the Spinal Cord," 1890; Ranney, "The Applied Anatomy of the Nervous System," p. 355; Ross, "Diseases of the Nervous System," p. 356; Charcot, "Localization of Cerebral and Spinal Disease;" Bramwell, "Diseases of the Spinal Cord;" Mills and Lloyd, "Pepper's System of Medicine," vol. v.; Mills, "Spinal Localization" (THERAPEUTIC GAZETTE, May 15 and June 15, 1889).

case of focal spinal lesion thought to depend on a tumor and not distinctly a malignant and generalized disease should be regarded as amenable to operative interference, no matter how marked or how long continued the symptoms of pressure may be.

D. The last group of cases, those of spinal traumatism, is extremely interesting when viewed from the operative stand-point.*

Operation in cases of injury was suggested as far back as the days of Paulus Ægineta, who taught that in spinal fracture the surgeon must, if possible, attempt to extract the compressing bone by incisions, having first warned the patient of his danger (Adam's translation). Ambrose Paré in the presence of paralysis made a like recommendation. Heister advised removal of any fragment that pressed on the cord. In addition, Hildanus, Matz, and Vigaroux all referred to the operation, though none of them preferred it, while Heine, Roux, Holscher, and Dupuytren each removed portions of the vertebræ for disease. Malgaigne says Chopart and Desault are the first to speak of it as a very simple thing "to trepan between the spinous and transverse processes, to give issue to effused fluids or to elevate or remove pieces of bone which may wound the cord;" but it is not recorded that their suggestions bore any fruit, and a long interval elapsed without further mention of the subject. Dr. James, in his "Medicinal Dictionary," London, 1745, said (in almost the same language employed by Heister),—

"If the spinal marrow is wounded, death follows inevitably. Though as it may seem cruel not to attempt the relief of one under these unhappy circumstances, the surgeon should lay the injured part bare by the knife,

* Here and elsewhere throughout this paper I have used freely the material contained in a former paper of my own on the same subject, adding largely to it and bringing the history down to date. (See "Annals of Surgery," June, 1888.)

and elevate the fragments, which press upon the medulla, in a proper manner; then let him cleanse the wound thoroughly and apply balsamic medicines, using the napkin and scapulary. He must continue this until the wound heals or the patient dies."

The nearest approach to a formal resection of the spine at about this date was the operation of Louis in 1762, reported in the *Arch. Générales de Méd.*, 1836, vol. ii. p. 417, and performed upon M. de Villedon, captain in the regiment of Vaubecourt, who was paralyzed from a gunshot wound of the back, received at the battle of Aménébourg. Louis and Duplessis consulted on the third or fourth day. They withdrew fragments of bone. They also spoke of "the indication for the trephine, even without fracture, to give exit to blood or matter, or even to prevent suppuration in some cases of fracture." M. Villedon recovered and was finally able to walk. Louis concludes, "Quoi qu'il en soit, c'est une victime que l'art a soustrait à une mort certaine."

The formal operation for the removal of a depressed vertebral arch was, however, first performed by the younger Cline, in the spring of 1814, and, though unsuccessful, showed the practicability of such an operation; Cline considered (South's Notes to Chelius's Surgery) that the symptoms sometimes resulted from the pressure of the spinal cord by the spinous process or arch of the displaced vertebra, either fractured or not, a condition which he thought analogous to that of the brain when a piece of the skull is driven in upon it and causes symptoms of compression, which are relieved by the removal of the cause of the compression. With this notion he held it feasible to remove the compressing vertebral arch, and so to relieve the palsy. In the clinical lecture which he delivered he explained the reasons which had induced him to perform this operation, and the grounds upon which he hoped for success.

He considered that in fracture with displacement of the vertebræ, which compressed the spinal cord, this great nervous cord was under precisely the same circumstances as the brain when pressed by fractured skull, and that, therefore, as the elevation of the pressing bone was indicated in the latter case, and often effected with success, so was it equally called for in the former, and that

no positive reason could exist why the operation should not be successful, provided the injury of the spinal cord itself were not great, a condition which, as regarded the brain, could equally forbid operation, or render its success improbable or impossible. Before undertaking the operation of cutting out that part of the arch of the vertebra which compressed the cord, Cline proposed to himself the following four questions, to which he gave the annexed replies: (1) Will the patient die of the operation? Probably he will, if the injury be severe.* (2) If the cord be much hurt, will it recover its functions? This is unknown; but we do know that if a nerve be divided it will unite, and the greater part of the spinal cord may be divided in a brute and yet the animal recover; in proof of which he detailed an experiment which he performed on a bitch. (3) After the removal of the arch of the vertebra will the spine be sufficiently strong to support the body? Probably it will for ordinary purposes, though the patient may not be able to lift heavy weights. (4) Will a patient recover from a compound fracture of the spine, which, by the performance of the operation, it becomes? The nearer a fracture is to the source of the circulation, and the less compact, and consequently the more vascular, the bone is, the greater is the probability of recovery. Both these advantages are present in the spine, and therefore favor the successful issue of the case. He added that the only reasonable objection to the operation of trephining the spine is, that we cannot, previous to the operation, ascertain whether the spinal cord is simply compressed, or whether it is partially or entirely torn through, or whether the symptoms of compression result from the effusion of blood in different situations, neither of which indeed can be ascertained after the vertebral canal has been opened, unless the sheath be rent.

Cline's operation, although his patient died, attracted great attention, and for a time its propriety was vigor-

* South says, "I do not exactly understand the answer given, for there is no danger in the operation, if it be performed with care; but I suspect he thought the exposure of the spinal cord might hasten inflammation, and so death might more quickly result."

ously discussed. An earnest argument, often degenerating into bitter and virulent personality, was kept up for many years, Sir Astley Cooper, Benj. Bell, Tyrrell, South, and others endorsing and upholding the operation, while Sir Charles Bell, John Bell, Sir Benj. Brodie, and others violently opposed it. The following quotations give an idea of the tone of a portion of the papers which were published about that period. Brodie wrote of the operation that "even under the most auspicious circumstances it must be doubtful whether it may not be productive of harm rather than of good to the patient;" while Sir Astley Cooper concludes his remarks on the subject as follows: "Though I may not live long enough to see the operation frequently performed, I have no doubt that it will occasionally be performed with success. There is no reason why it should not; and he who says that it ought not to be attempted is a blockhead."

After a time, however, the controversy languished, although here and there a solitary operation, almost invariably entirely unsuccessful, was recorded.

Dr. Alban G. Smith reported a case in which portions of the third dorsal vertebra were removed for relief of paralysis from fracture. At the time of the report, bed-sores, from which the patient had previously suffered, had healed, and there was return of sensation (*North American Medical and Surgical Journal*, July, 1829, vol. viii. pp. 94-97).

In the *British and Foreign Medical Review* for 1838, in a critique of Sir Charles Bell's "Institutes of Surgery," the reviewer quotes a successful case, in which the operation was performed by a Welsh surgeon by the name of Edwards, resection having been made in the lumbar region. The case, however, is very imperfectly reported. The cases of Tyrrell, Barton, Wickham, Smith, Rogers, and others were all unfavorable, and Malgaigne, after having reviewed their results, joined the ranks of the opponents, deciding that the fatality of the recorded cases should be sufficient to deter surgeons from so grave an operation. He believed that if the ordinary methods were not sufficient in a case of fracture with displacement, we might try to act on the posterior fragment with forceps or tenacula

to draw it backward, but that "the extraction or trephining of the arch presents itself as so desperate a resource" that he would not advise any one to adopt it.

Mayer reports a case of paraplegia following injury in which he removed a portion of the sixth and seventh dorsal vertebræ with some temporary improvement, but followed by death on the twenty-first day with all the symptoms of sepsis (*Journal der Chirurgie und Augenheilkunde*, Berlin, 1848, vol. xxxviii. pp. 162-200).

In 1861, Dr. Hutchison, of Brooklyn, published (*American Medical Times*) the history of an operation for fracture, which resulted in death, and reviewed the histories of the recorded cases up to that time. He did not arrive at any general conclusion as to the propriety of surgical interference.

Dr. A. A. Potter reports three cases of operation for paralysis following fracture. In one of them no improvement followed. In another death resulted in four days. In the third, in which there had been complete paralysis of motion and sensation, a perfect recovery was effected (*American Medical Times*, 1863, vol. vi. pp. 17, 18).

Laugier (Felizet, *Archiv. Gén. de Méd.*, October, November, and December, 1865), on the fourth day after a fracture of the spine, removed the eighth dorsal spinous process, which was broken, and trephined the arch of the ninth dorsal vertebra. The patient died on the fifth day after the operation. Fracture of the body of the eighth dorsal and comminuted fracture of the body of the ninth dorsal vertebra were found.

In 1865 considerable attention was again drawn to the operation by Dr. Robert McDonnell, who reported the case of Dr. Samuel Gordon, in which trephining of the twelfth dorsal vertebra had been followed by the healing of a bed-sore, the disappearance of a virulent cystitis, and the return of power over the bladder and of sensation in the rectum, the patient being still alive, but unable to stand, at the end of five months.

Dr. McDonnell also reported a fatal case of his own, and reviewed twenty-six cases of trephining, in seven of which life was preserved for a long time. He called attention to cases of temporary paralysis from pressure by pus, in which the cord had entirely recovered, and to

similar ones of paralysis from wounds of the spine, followed by recovery on the withdrawal of the foreign body which was causing the compression.

He concluded that instances of fractures of portions of the vertebræ, unaccompanied by fracture or displacement of the body, are not very infrequent, being ten per cent. of the recorded cases which he was able to discover, the majority of them occupying the cervical or upper dorsal region.

He suggested that the loss of reflex movement in such patients might be due to a venous congestion of the cord below the seat of injury, not to structural change, and that such loss is therefore an additional indication for operation.

He thought that evidences of myelitis or meningitis, the girdle symptom, formication, cramps, spasms, fever, etc., contraindicated operation; but believed that the softening of the cord under pressure was quite different from ordinary inflammatory softening or "white softening," and that it indicated no structural change from which the cord could not recover.

In the discussion in the Royal Medical and Chirurgical Society (*Medical Times and Gazette*, December 9, 1865, vol. ii. pp. 639, 640) which followed the reading of Dr. Gordon's paper, Mr. Alexander Shaw called attention to the fact that in this successful case the operation was not performed until the second month after the accident, during which time the vertebral column must have undergone essential changes; so that, if the bones had not perfectly united, at least all the adjacent parts must have become consolidated by the processes of repair.

"And," he added, "observations show that when patients have passed through the first stages of the accident, and have lived long enough for the injured parts to acquire some solidity and firmness, their chances of surviving, although with paraplegia remaining, are greatly increased; the probable reason being that, as they can be moved more freely in bed, and their positions more frequently changed, the bed-sores are more likely to be cured."

In the same year Felizet (*op. cit.*) reviewed twenty-six cases, and reached the following conclusions: 1. The

cause of death after fracture of the vertebræ is the compression or continued irritation of the spinal cord. 2. The operation should not be held responsible for the subsequent symptoms, as they are equally grave in cases where no interference has been practised. 3. Trephining, on the contrary, conforms to physiological conditions, causes almost immediate improvement if the cord were not completely destroyed, and in those cases where it fails, the failure is almost always due to the gravity of the traumatism itself.

In 1866, Mr. Jonathan Hutchinson ("Clinical Lectures and Reports of the London Hospital," vol. iii. p. 327) considered at length the conditions usually met with in spinal fractures and luxations, with the object of furnishing conclusive arguments in support of the usual practice at the London Hospital, of abstaining from operative interference in such cases.

He asserted that a great many cases recover, if put under favorable circumstances and let alone, and that of those which end in death, very rarely indeed could it be said, after post-mortem examination, that an operation could by the barest possibility have done any good. In the great majority, then, since it could have done no good, its effect would have been to increase the patient's sufferings and aggravate his danger.

With regard to the lesions usually met with in the post-mortem room, he made the following assertions, based on the examination of about twenty cases: "1. Permanent compression of the cord, or of any part of it, is a very rare event. From my experience I should not think that permanent displacement to any material degree is met with once in ten cases. 2. As might be expected from the fact that almost all the more serious injuries to the spinal column are due to indirect violence (bends), the fractures of the laminæ are of little consequence, and never cause compression of the cord. In almost all our cases the laminæ, spinous processes, etc., are more or less fractured, but I have never yet seen a case in which any of the fragments were in contact with the cord. 3. Having thus denied that the cord is permanently compressed, either by the bodies or the laminæ, I now extend my statement to extravasations of blood. I have never myself seen any effusion to the

extent of possible compression, and in the majority of cases there is little or none. The injury is a crush, and is not one at all likely to cause much bleeding. There are no large arteries to be injured. 4. Instances of great displacement of one vertebra do sometimes occur. They are exceptional, however, and very rarely of a kind which we could rectify by force or by operation. 5. The cases in which during life there is evidence of considerable displacement are not by any means always the most serious ones. The irregularity, perceived externally, concerns rather the spinous and transverse processes than the bodies, and it is very possible that they may have been fractured without any crush of the cord; and, on the other hand, that the bodies may have been displaced for a moment, allowing complete crushing of the cord, and yet no permanent irregularity may have resulted. In justification of the strong opinion I have already expressed against operations with the intention to elevate depressed portions of bone, I must say a few words more. *My chief reason is that by doing so you convert a simple into a compound fracture, and add the risks of pyæmia, together with those of spinal meningitis.* Then I urge that depressions of bone very rarely exist, perhaps not one in twenty cases, and that it is utterly impossible to select the case."

Mr. Maunder reports the case of a man aged 28 who, having paraplegia as a result of an injury, was operated upon nineteen days later.

The spines of the first and second dorsal vertebræ were cut off, and the corresponding laminæ removed by the trephine and bone-forceps. The patient died of pyæmia on the thirteenth day. At the autopsy, the cord was found to be "pulped" opposite the lower border of the seventh cervical vertebra (*London Lancet*, 1867, i. pp. 237, 238).

In 1867, Dr. John Ashhurst reviewed the subject up to that date, publishing a table of twenty-six cases, many of which were included in Dr. Hutchison's and Dr. McDonnell's collections, reviewed their clinical history, said that there was not in fact one well-authenticated instance of recovery from spinal resection, and concluded that in no case did resection or trephining

offer a reasonable prospect of improving the patient's condition; but that, on the contrary, there was reason to fear that they increased the chances of fatal termination.

In 1869, Mr. Thomas Nunneley, in an address on "Surgery" before the British Medical Association, again brought the subject to the attention of the profession. He said that while the great majority of surgeons had had an unfavorable opinion of the operation of resection of the spine after fracture or dislocation with symptoms of compression, and while for many years it seemed to have been almost forgotten, yet he could not but think that this position had resulted more from submission to habit or to traditional authority than from a due consideration of the subject. He reported four cases of his own with one recovery, reviewed the tables of McDonnell, and concluded that out of thirty-three cases of fractures in various parts of the spine, life had been permanently saved in three and considerably prolonged in three others, and that in still others general improvement had resulted. He called attention to the fact that all the successful cases were most unfavorable at the time of the operation, and should, therefore, not be compared with large collections of injuries to the spine, of all grades of severity. His general conclusion, therefore, was distinctly favorable to the operation, and he quoted with approval the dictum of Sir Astley Cooper, who, more than once, declared that if one patient out of one hundred could be saved it would be better than could be hoped for from nature alone. During the same year, however (1869), Mr. LeGros Clark, in a lecture on "Diseases of the Spinal Cord" (*British Medical Journal*, July 17, vol. ii. pp. 49-52), took equally strong ground against the operation. His argument may be summarized as follows:

The end proposed in an operation of this kind is to remove displaced bone which is supposed to press upon or irritate the cord. But such a proceeding is most likely to prove abortive from the inaccessibility of the displaced bone, fractures of the arches alone being very rare except from direct violence. But the direct violence which would suffice to fracture the arch and drive the spinous process into the cord, the body of the vertebra remaining unbroken, must almost inevitably prove hope-

lessly destructive to the nerve-tissue. Again, if the surgeon operate early, he does so before it is known whether the injury is permanent, a fact which can only be developed by time; if he wait he diminishes his chances of success. If he does operate, he converts a simple fracture into a compound fracture, and a communication is established with a canal having the most delicate and susceptible relations, and which must be liable to the intrusion of the products of inflammation during such period as the patient may survive the effort to repair the lesion. If the cord has been crushed, and the operation has been consequently useless, probably life may be thereby only curtailed; but if (as must be presupposed for the operation to have a chance of success) the cord be not crushed, it appears that the best chance for the patient's recovery is merely extinguished. The operation has been advocated on the *erroneous hypothesis that the spinal cord can be compressed without serious disintegration of its texture. I believe this is scarcely ever the case*, unless such pressure result from extravasation of blood, a condition which, if it could be ascertained, would not be regarded as indicating operation.

The only supposable form of spinal surgery which, in my opinion, might be benefited by operation is a fracture of the vertebral arch alone, with limited depression, or the recent intrusion of a spiculum of bone within the theca, whereby the cord is pricked and irritated. But where are these cases to be met with, and how are they to be recognized? I fear we must abandon this operation. It can scarcely be alleged by its advocates that, if unproductive of good, it is harmless. To weaken still further the remaining connections of a broken spine, to convert a simple into a compound fracture, to expose the sheath of the cord, and possibly the cord itself, and to entail the risks attending the period of repair, cannot be regarded as circumstances of indifference.

At present, with every disposition to regard this subject impartially, and to give their due weight to the arguments and facts which have been advanced in its favor, I cannot regard trephining the spine as brought within the pale of the justifiable operations in surgery.

In 1870, M. Brown-Séquard, from the point of view

of a neurologist, as well as of an experimental physiologist, upheld very strongly the theory that death after fracture of the spine is usually due to the effect of continued irritation of the cord by pieces of broken bone, and not to the results of a partial or complete section of this nervous centre ("Physiology and Pathology of the Nervous Centres").

He quoted the clinical history of many cases to prove that section, or even crushing of the spinal cord, had not proved fatal, and emphasized the fact that in animals death is rarely caused by complete section of the cord in the dorsal region, while they die as quickly and as often as men after fracture of the spine if the broken pieces are not removed. He further called attention to the removal of the body of the third cervical vertebra by an Italian surgeon in a case of syphilitic caries, to another analogous case also operated upon by an Italian surgeon, and to two cases of cyst in the spinal canal with erosion and expulsion of portions of the vertebræ, all of which recovered.

He believed that, as the result of his investigations, the following conclusions were justifiable: 1, that the laying bare of the spinal cord was not a dangerous operation; 2, that death after a fracture of the spine is usually due to the effects of pressure, or of excitation of the spinal cord, and is not the result of a partial or a complete section of this organ; 3, that reunion may take place after a wound of the spinal cord, so that its lost function may return; 4, that the removal of some parts of the vertebræ may be followed by a production of new bone; 5, that the cases of fracture of the spine in which the trephine has been applied show the usefulness of this operation.

In spite of this pronunciamiento, another long interval ensued, with very few reported cases which I have been able to discover of resection of the spine in case of injury. Two cases in 1870, operated on by Cheever, of Boston, both resulted fatally, as did one operated on by E. R. Willard in 1871, and one by Lucke in 1880. Stemen, of Indiana, in 1883,

reported three cases,—one relieved, one not benefited, one fatal in eight days.

In 1884, Dr. John A. Lidell, in the article on "Injuries of the Back," in volume iv. of the "International Encyclopædia of Surgery," quoted Ashhurst's statistics, recorded the statement of Professor Eve, of Nashville, to the effect that the operation of resection of the dorsal vertebræ is "one of the most difficult in surgery, if not impracticable," and concluded that the operation of resection or trephining the vertebræ is unjustifiable, because it does not offer a reasonable prospect of improving the patient's condition in any case, while, on the other hand, there is always reason to fear that it may increase the chances of a fatal termination.

In September, 1884, Dr. Halstead, of New York, operated at the Roosevelt Hospital on a patient who, three days previously, had suffered a fracture of the spine of the twelfth dorsal vertebra, with rotation and forward luxation of the body of the same vertebra and fracture of the right transverse process of the first lumbar. The displacement was reduced with the help of Langenbeck's hook, but the patient died seventeen hours later (*Medical News*, January 3, 1885).

In November, 1884, Dr. Pinkerton, acting as house-surgeon for Dr. E. L. Keyes, removed the spinous process and lamina of the twelfth dorsal vertebra, which had been fractured four days previously. The patient died five days later (*ibid.*).

In February, 1885, Mr. William Macewen (*British Medical Journal*, August 11, 1888) operated in the case of a man who, six or eight weeks previously, had had a severe injury to the spine at the level of the lower dorsal vertebræ. He had absolute motor paralysis, incontinence, hyperæsthesia followed by anæsthesia, rapid muscular atrophy, cystitis, bed-sores, pyrexia, etc. Resection was performed. The arch of the twelfth dorsal was

found fractured and depressed. A connective-tissue tumor between it and the theca was removed, as well as the laminæ involved. The patient made a good recovery, and a year later could walk about with ease and without support.

In 1886, Dr. Robert T. Morris reported ("Annals of Surgery," June, 1886) the case of a patient who, as the result of a fall upon the head, had complete paraplegia, with loss of sensation and of motion at nearly all points below the neck. Two years and three months after the accident the laminæ and spinous processes of the seventh cervical vertebra and the spinous process of the sixth cervical vertebra were removed. The patient lived ten months, but was not materially improved. At the autopsy very extensive disease of the cord itself in the neighborhood of the injury was found. The membranes were thick and firmly adherent to each other and to the vertebræ.

In 1886, Dr. Carl Lauenstein, of Hamburg, reported (*Centralblatt f. Chirurgie*, No. 51, 1886; *London Med. Record*, March 15, 1887) the case of a patient who, five weeks before coming under observation, had had a fall of forty feet. This was followed by paraplegia, incontinence of urine and fæces, trophic changes, etc. There was a projection in the dorso-lumbar region, most prominent over the spine of the last dorsal. The use of a plaster jacket had failed to give relief. The arches of the last dorsal and first lumbar vertebræ were removed by means of a chisel.

Six months later the patient was able to walk, the incontinence had disappeared, and he was reported as quite recovered.

With the view of deciding the question whether such improvement as had resulted in this case could possibly be attained without the performance of a surgical operation, Lauenstein reviewed the published reports of similar cases, and studied especially the statements referring to paralysis of the bladder. The relief of this condition, he states, is a point of much importance, for, with the exception of bed-sores, which usually occur in such cases, cystitis is, undoubtedly, the most formidable of all the secondary symptoms. Of fifty-three cases of so-called cure of fracture of the spine, collected by Gurlt in his work on fractures, there are fifteen instances

of spontaneous restoration of the functions of the bladder and rectum. The shortest interval between the date of the accident and that of complete restoration of the functions of these organs was a few hours, and the longest interval eight weeks.

In not one of six cases of fracture of the spine with paralysis of the bladder, treated by Lauenstein during the last six years, was any spontaneous improvement observed in this latter condition after long intervals. It is concluded from these returns that when, in cases of compression of the cord from fracture of the spine, the functions of the bladder and rectum are restored, this restoration usually takes place after a brief interval, and that if no improvement has taken place in the course of ten weeks, any subsequent spontaneous change for the better in the condition of the bladder can hardly be anticipated. In the case reported by Dr. Lauenstein the bladder symptoms just before the operation were increasing in severity.

Since the introduction of the antiseptic method into practical surgery two other instances in addition to Mac-ewen's and Morris's cases had been reported up to this date (1887) of operative interference for the relief of paralysis from injury to the spine.

The first of these, reported by Maydl, from the hospital practice of Albert, was a case of resection of the ninth and tenth dorsal vertebræ for paralysis following fracture. The dura was opened, but nothing abnormal was seen. The cord was, however, compressed from the upper border of the tenth to that of the ninth vertebra, partly through the fracture of the body and partly through a bilateral luxation between these two vertebræ. The patient recovered from the operation, but was not improved (*Wiener Med. Presse*, 1884, vol. xxv. pp. 1336-1340).

In the second case, reported by Lucke, the operation was performed two days after an injury to the spine, which was found to consist in fracture with crushing of the corresponding part of the cord. This patient also recovered from the operation, but died nine months later from marasmus, and without any but very slight improvement having been observed in the condition of the paralyzed limbs. In six only of thirty-one cases col-

lected by Werner of operations performed on fractured spine in the pre-antiseptic era did the patients recover from the effects of the operation. These results, however, Lauenstein held, cannot be brought forward to discredit the operation of trephining the spine, since sufficient care was not taken in their selection; and the treatment was applied in instances both of recent and of old injury, and even of complete crushing of the cord.

Lauenstein would not operate in a case of recent injury to the spine, as it is well known that occasionally in such instances the symptoms of paralysis disappear spontaneously in the course of a few weeks.

Severeneau reports a case of shot-wound of the back with fracture of the second dorsal vertebra, paralysis of all four extremities and of the bladder and rectum. The ball was recognized with the help of an electrical apparatus and was extracted. Paralysis disappeared, and the patient entirely recovered (*Archiv für Klin. Chirurgie*, 1888, vol. xxxvii. pp. 664, 665).

In the *Edinburgh Medical Journal* for March, 1889, Mr. John Duncan reports three cases of fracture of the spine with paralysis which were operated upon by removal of the laminæ of the broken vertebræ. One case died on the following day; the others recovered from the operation, but were unimproved.

Horsley, in a foot-note to his paper on the case of spinal tumor, says he has operated on a case of fracture, and that the wound healed rapidly, but gives no other details. In the paper itself he also mentions a most interesting case of operation for paralysis following fracture, in which the wound healed rapidly, as did a large bed-sore. There was but little general improvement.

It was found in this case that the spinous process of the eleventh dorsal vertebra was jammed forward between the tenth and twelfth, and also that there was backward compression of the cord against the lamina of the tenth vertebra. These were removed. Mr. Horsley makes the following remarks apropos of these cases, and with reference to the dictum that when there is evidence that the cord has been severely jammed or compressed at the time of accident, an operation is contraindicated:

“In this case no doubt the spinal cord was momenta-

rily jammed at the time of the accident so severely as to practically—*i.e.*, functionally—divide it. Though laminæ were found compressing it at the time of the operation, nevertheless they did not do it so severely as to thereby alone cause the excessive degree of the symptoms, therefore it would seem that the cord, as suggested, must have been compressed at the time of the accident. Now, this is just a case in which, if any attention had been paid to the ruling before quoted, the patient's life would have been lost, and indeed it must be obvious that, considering the necessarily small amount of information on this subject, it should be our duty to operate in every case, since we may possibly do some good, and certainly, if proper antiseptic precautions be taken, we can, to use Mr. Erichsen's words, do no harm.

This question of the damage to the spinal cord not appearing to discount the possible benefit of surgical interference so much as has been hitherto expected, gains additional illustration from the case which forms the subject of this paper, since nothing could well have appeared more hopeless than the indentation of the spinal cord produced by the tumor. This indentation appeared to divide the lateral column completely, and yet, owing doubtless to the gradual character of the compression, the restoration of motor and sensory function has been complete. I would repeat, therefore, that, so far from its being unjustifiable to operate on the spine owing to the possibility of the cord being hopelessly damaged, it seems to me to be criminal not to operate."

Dr. Ewing Mears has reported (*Medical News*, December 22, 1888) a case of fracture in which he removed the left lamina of the first lumbar. Motion returned in the left foot and leg.

Mr. Ernest Hart reports (*British Medical Journal*, March 23, 1889) a case of Péan's in which paraplegia, retention of urine, etc., followed a severe contused wound of the mid-dorsal region caused by the bite of a horse. The spinous processes of the seventh and eighth dorsal vertebræ were not to be felt. Péan removed by operation the fragments of these processes, and of the corresponding laminæ which had pierced the membrane and entered the substance of the cord itself. He resected the irregular ragged fragments of the trans-

verse processes. Mr. Hart reports that the operation was completed without complication, and that "the patient is now restored to almost his ordinary condition."

Mr. Herbert Allingham reports (*British Medical Journal*, April 13, 1889, p. 838) two cases of fracture of the spine treated by trephining. In one there was fracture with depression of the laminæ of the sixth dorsal vertebra; the spines and laminæ of the fifth, sixth, and seventh were removed. The wound healed in ten days. The symptoms of ascending changes were checked. Improvement to some extent occurred.

In the second case the spines and laminæ of the third, fourth, fifth, and sixth dorsal vertebræ were removed; the wound healed in a fortnight. No mention of the subsequent course of the case is made except the fact that the woman died seven weeks later, and that the cord was found almost divided.

Dr. Robert Dawbarn has reported (*New York Medical Journal*, 1889, vol. xlix. p. 711) a case of paralysis following fracture at the dorso-lumbar junction in which he operated, finding depression of the lamina of the eleventh dorsal vertebra and a fracture of the body of the twelfth dorsal vertebra, which had in part been thrown backward. The depressed lamina was firmly adherent to the theca, and on removing it it was necessary to saw and to elevate the posterior arch of the tenth dorsal vertebra. The cord was found in the shape of a distinct knuckle making an angle of fifteen degrees, its apex pointing backward and lying immediately below the depressed arch. The tenth, eleventh, and twelfth arches and laminæ were removed. The dura was not opened. Ten weeks after the operation all motion and reflexes were still absent. The muscular sense was improved. The power of the bladder was markedly increased. The rectal sphincter was regaining strength. Pain upon motion had largely disappeared. The temperature of the legs had much improved.*

* Dr. Dawbarn thinks that we may now advance the following statements as a rule of practice: "Whenever, following traumatism, even a slight abrupt irregularity of the spinal column is observed to coexist with paraplegia from this level, a cutting operation is indicated to deter-

Dr. J. E. Richardson reports (*Brooklyn Medical Journal*, 1889, vol. iii. pp. 401-416) the case of a man, aged 22 years, who had a swelling upon the back of the neck, extending from the third to the seventh cervical vertebra. There was stiffness of the neck, with limited movement of the head and pain on pressure over the cervical spine. After this had lasted for about ten months he began to complain of numbness of the hands, and paresis of the sphincters of the bladder and rectum and of the lower extremity, which finally increased to almost absolute paralysis of both upper and lower limbs. As soon as the patient was anæsthetized, the tumor over the neck instantly disappeared, and it could then be seen that it was caused by the contraction of the muscles of the neck in their endeavor to hold the head and neck erect.

An incision was made extending from the occipital protuberance to near the spine of the seventh cervical vertebra, and, dissecting down to the spinous processes, the lamina of the fifth cervical vertebra was removed with the trephine. The cord was then distinctly seen. It was supposed that there might be an accumulation of pus within the spinal canal, the evacuation of which would remove the pressure. It was found, however, that none existed, and it was decided to do nothing further. The operation was performed antiseptically, and the wound washed out with a solution of bichloride, 1 to 2000; a drainage-tube was inserted into the wound, and the latter then closed and dressed. There was decided

mine whether the paralysis is not, by bony pressure, made incapable of spontaneous relief.

“This operation should be deferred no longer than recovery from the original shock of the injury demands. If needed at all, it is needed early; and we make a mistake if, as in my case, we wait until electricity and time have alike proved futile before attempting what I may call exploratory resection. It will be the easier by far to the surgeon at this early stage, and the safer for the patient; at least when the obvious displacement is due to a broken posterior arch, as then comparatively little bony section would be needed, the fragments not having become consolidated by bony union in their false position.”

improvement in sensation immediately after the operation, but death occurred four days later.

Passed Assistant Surgeon S. T. Armstrong reports ("Reports of the U. S. Marine Hospital Service," 1889, pp. 271, 272) a case of fracture following extreme flexion in which there were complete paralysis, bed-sores, hectic, etc. On October 8 the patient was chloroformed, and resection of the vertebræ was made. An incision was made over the spines of the last dorsal and first lumbar vertebræ, the muscular mass dissected away, and the spines of the twelfth dorsal and first lumbar vertebræ removed, exposing the canal. The membranes of the cord appeared normal, the cord itself being atrophied, and there was no septic fluid in the canal. The anæsthetic was discontinued during the operation, and, as there was anæsthesia of the tissues, the operation was completed with chloroform. There was a "perceptible angling" of the vertebral column, but no pressure was exerted on the cord. The wound was accordingly dressed antiseptically, further operative interference not being indicated.

No improvement in sensation or motion followed the operation. The hectic fever caused by the large granulating and suppurating sores produced by the vasomotor paralysis continued. The patient died October 15. The autopsy showed septic abscesses in various places, and the following condition of the spine itself. On removing the vertebral column a fracture of the body of the third dorsal vertebra was found, almost the entire right half of the body being absorbed. There was also a fracture of the anterior superior edge of the body of the twelfth dorsal vertebra. No fracture of other bones.

In this case the operation was of no benefit, for the pressure on the cord in the region of the twelfth dorsal vertebra was demonstrated as of small consequence. The fracture of the third dorsal was unrecognized during life. At the necropsy no pressure of the cord was found at this site. The large ulcerating surfaces offered an excellent opportunity for septic infection, and it was impossible to heal them on account of the trophic disturbance.

Dr. James Bell reports (*Montreal Med. Journal*, 1889, vol. xix. pp. 911-913) the case of a man, aged 40, who, as the result of a fall, had complete paralysis below the arms and partial paralysis of these extremities. Resec-

tion of the laminæ of the fifth and sixth cervical vertebræ was practised, and the dura mater was picked up and incised: a considerable quantity of a reddish cerebro-spinal fluid escaped; the cord looked normal on its surface; no evidence of traumatism was to be seen. The patient made a good recovery from the operation, but died suddenly three days later. Post-mortem examination showed a portion of the cord, about three-quarters of an inch long, opposite the sixth cervical vertebra, soft to the touch. No dislocation of the bodies of the vertebræ, and no separation of the posterior ligament.

In another case Dr. Bell resected the lower cervical vertebræ in a case of paraplegia after accident, and found one inch of the cord substance very badly crushed. The operation was therefore terminated. The patient recovered from it, but died comatose three days later from respiratory failure.

Dr. N. P. Dandridge has reported (*Journal of the American Medical Association*, 1889, vol. xiii. pp. 37-43) five cases of fracture of the dorsal spine. In three the plaster jacket was applied, with satisfactory results in two. In one great improvement followed rest in an ordinary bed, increasing markedly several months later by systematic suspension. In one case the tenth, eleventh, and twelfth dorsal and first lumbar arches were removed. The dura was not opened.

At the upper portion of the wound the cord seemed to be diminished in consistency. The wound healed after slight suppuration, although some improvement followed. Dr. Dandridge thinks that it was due to the assiduous care and attention the patient received, and not to the operation. "In this connection it is a matter of interest and importance to determine after what length of time we must give up all hope of the disappearance of paraplegia in Pott's disease. I desire to place on record a case bearing on this point, in which after complete paralysis for more than three years and a half voluntary power returned, and six months later the child was able to walk with a slight support. The child, now 7 years old, has been under continuous observation for years at the Children's Hospital, Cincinnati, with marked curvature in the upper dorsal region. On admission there was complete loss of power in both lower

extremities, but neither incontinence nor bed-sores. This condition continued without improvement until six months ago, when motion began to appear, at first in the thigh-muscles; now he is able to stand, and with slight aid to walk. The improvement has been continuous, and complete restoration seems probable. For nearly two years the treatment has been little more than proper nourishment and good hygienic surroundings. The case has made a deep impression on my mind, as showing the power of recuperation possessed by the cord."*

* After a review of his own and other cases of fracture, Dr. Dandridge formulates the following provisional conclusions: "1. In fractures of the cervical vertebræ there is indicated immediate reduction of any displacement by extension and manipulation under an anæsthetic, followed by continuous extension and immobilization.*

* Dr. Herbert Burrell, in a valuable paper read before the Massachusetts Medical Society, June, 1887, has recorded the results of immediate rectification of the deformity and fixation of the spine by means of a plaster jacket. He details sixteen cases, in which three died, three derived no benefit from the method, and ten were greatly benefited. He arrives at the following conclusions:

1. That in the immediate correction of the deformity and fixation with the plaster-of-Paris jacket or other means we have a rational method of treating a large number of cases of fracture of the spine.
2. That, considering the hopelessness of results in fracture of the spine when treated expectantly, almost any risk is justifiable.
3. That the immediate correction of the deformity is imperative, as softening of the cord can and does occur from pressure at the end of forty-eight hours.
4. That the suspension of the patient is only a means of rectifying the deformity; that certain fractures could be simply pressed into position while the patient lies prone or supine.

The objections to the treatment are: 1. That the expectant plan of treatment gives a small percentage of recoveries. 2. That there are, especially in the cervical region, serious risks attending the suspension of a patient with a fractured spine and the rectification of the deformity,—in the way of shock, collapse, and death. 3. That in attempting to relieve pressure on the cord by rectifying the deformity, we might either sever the spinal cord or make pressure upon it. This is a matter of chance.

My own belief regarding the status which the procedure should occupy in surgery is, that it will occasionally be a life-saving measure; that it should be applied under anæsthesia in all cases of fracture of the spine which are not conclusively shown to be irremediable; and that, apart from the chance of recovery offered to the patient by this means, it will almost invariably make the patient more comfortable, in that he can be handled more easily.

Dr. Dunnavant reports (*Memphis Journal of the Medical Sciences*, 1889-90, vol. i. pp. 142-144) the case of a gunshot wound of the spinal cord in which the laminæ of the second and third dorsal vertebræ were shattered, and the cord itself completely severed. Operation was performed, and several spicula of bone removed. The patient died four days later.

Dr. Thomas H. Manley reports (*New York Medical Record*, 1890, vol. xviii. p. 202) the case of a fracture of the sixth cervical vertebra which was found on operation to involve the laminæ. The patient died at the end of the fourth day from consecutive hemorrhage. The cord at the autopsy showed no signs of traumatic or pathological disintegration.

Delorme reports (*Gazette des Hôpitaux*, 1890, vol. lxiii. p. 249) a case of wound of the base of the neck by a musket-ball. This was followed by suppuration, which lasted for seventeen years. Radiating pains were felt in the left upper extremity, and were localized in the left half of the neck. There was condensing ostitis of the lower portion of the vertebral column on the left side. Resection of the posterior extremities of the first four ribs on the left side was performed, and at the same time the spinous processes of the first dorsal and seventh cervical vertebræ and a portion of the laminæ and of the transverse processes of the latter vertebra were removed. A mass of callus was found in this region, and was removed at the same time. The patient was entirely relieved of the pains, which had previously

2. In all fractures of the dorsal or lumbar spine involving the bodies or the arches, with or without evidence of injury to the cord, the immediate application of the plaster jacket by the hammock suspension preceded, if there is evident displacement by an extension, under an anæsthetic. 3. When symptoms indicating injury to the cord persist without improvement resection is indicated. 4. Immediate operation would be indicated where there is marked depression of the arches with symptoms of paralysis. 5. Long continuance of the symptoms is not in itself a contraindication to operation. 6. We have in suspension the means of alleviating some of the sequelæ of fracture of the spine."

been almost unendurable, and made a complete recovery.

Dr. L. S. Pilcher has reported ("Annals of Surgery," 1890, vol. xi. p. 194) a case of fracture of the spine at the junction of the dorsal and lumbar regions, followed by rapidly-ascending paraplegia, and by rigors and fever. On the eighth day the spines and laminæ of the last three dorsal and first lumbar vertebræ were removed, exposing a partly-organized blood-clot about a line in thickness, lying external to the dura mater. The line of the fracture was through the dorso-lumbar articulation, with fracture of the spine and the laminæ of the last dorsal vertebra, but without depression or displacement. The patient died of asthenia thirty-six hours after the operation.*

* Dr. Pilcher, after reviewing the objections to the operation, adds: "I am, however, far from accepting the sweeping condemnation with which Jonathan Hutchinson and Le Gros Clark have declared all such operations unjustifiable. The reasons which prompted me to operate in the one case in which I did interfere I believe to have been valid and sufficient, notwithstanding the fact that no special benefit accrued to the patient from the attempt. Fractures of the spine in which the lesion is caused by a force which acts only upon a very limited segment of the column evidently form a class much more likely to present conditions amenable to operative interference than cases in which the injuring force is more diffused. The injury to the cord will be much more limited in extent; the presence of depressed fragments pressing into or upon a wounded cord is more likely to exist; no extensive resection of the posterior arch of the canal will be required. And those cases in which the bone injury is limited to the spinous processes and laminæ form a class which should be distinguished clearly, as regards the possibilities of advantage by operative interference, from the cases in which there is complete fracture through the bodies of the vertebræ. As is well understood, in many cases of complete fracture—illustrated in the two cases above detailed—the soft structures which bind the bones together posteriorly are not ruptured, and continue to form a most important

Dr. Robert Abbé reports (*New York Medical Record*, 1890, vol. xxxiii. p. 85) three cases in which he operated for paraplegia from fracture. In one there was paraplegia below the eleventh dorsal of two and a half years' duration; the patient died thirty hours after operation. In another there was a fracture of the eleventh dorsal vertebra with paraplegia. At the operation the dura was opened. The patient recovered, but remained unimproved. In the third, three arches, the tenth, eleventh, and twelfth, were cut through and the spinal cord laid bare for two and one-half inches. The twelfth dorsal vertebra was found to have been displaced backward, the fracture running through the articular facets, the pedicles and laminae. The cord was compressed between the arch of the eleventh above and the upper lip of the body of the twelfth below. The intervertebral cartilage had been ruptured. Above the line of pressure the cord pulsated, below it did not.

In half a minute after the cord was released from its flattened state (the bone-pressure area being only half an inch deep) the dura became rounded up as full as it was above or below. When it was filled out there was no surface appearance by which one might say that the cord within was not normal, except that the upper portion pulsated. Dr. Abbé emphasized this point because

bond to prevent displacements in the subsequent history of the case. To divide these, as is necessary if the spinal canal is to be opened, entails the destruction of this means of support which cannot be adequately substituted, and is a sacrifice which ought to be made with great caution and only on the clearest evidence of the existence of a more imperative indication. If, however, the bodies are intact, or if the case has progressed to a period in which consolidation of any fracture involving them has occurred, then the posterior arch may be attacked without seriously increasing the hazards of the case. Gunshot fractures of the vertebræ form yet another class, one in which there is the special indication arising from a compound fracture, probably septicallly infected, for immediate enlargement of external wound, removal of fragments of bone, disinfection, and drainage" ("Annals of Surgery," 1890, vol. xi. pp. 196, 197).

surgeons so often have reported that the cord appeared normal, and therefore they did not open the dura. The wound now being irrigated and dried, the dura was slit up for two inches. Adhesions of various densities were found within, attaching the meninges to the dura, and they formed a complete circular dam, shutting off the upper from the lower part of the canal. Only an ounce of clear spinal fluid came out, as the spinal canal had purposely been inclined on the table so as to prevent this. The veins of the cord were not distended. The adhesions were, with very little force, broken up. The cord was normal in thickness above the involved part, then, by a sloping rather than an abrupt change, it merged into a flattened cord for three-fourths of an inch, retaining its breadth but less than half its thickness, the principal atrophy seeming to be in the posterior columns. Throughout this flattened portion the white fasciculi of the cord could be traced continuously, so that there was no abrupt break in its continuity. The patient recovered from the operation, but remained unimproved.

Jaboulay reports the histories of two patients suffering with indirect fracture of the spinal column on whom he operated. In one there was a fracture of the sixth dorsal vertebra. The symptoms were extremely urgent and becoming more so. At the end of two days the arches of the fifth, sixth, and seventh dorsal vertebræ were raised, and the dura mater incised; a quantity of blood escaped from the sub-arachnoid space. The patient lived eighteen hours. The second patient, a woman 38 years of age, had a fracture in the dorso-lumbar region. She was paraplegic, had bed-sores, and had a fracture of both bones of one leg, which at the end of four months did not show the least trace of consolidation. The operation consisted in the removal of the arches of the twelfth dorsal and first and second lumbar vertebræ, together with a fragment which completely obstructed the lumen of the spinal canal. One month afterwards the œdema of the legs had disappeared and the fracture of the leg had healed, no apparatus having been applied. The patient died five months later. In both these cases the marrow was much softened at the level of the fracture (*Lyon Médical*, 1890, vol. lxiv. pp. 265-269).

Thorburn has reported ("A Contribution to the Surgery of the Spinal Cord," 1890) five cases of trephining for injury.

CASE I.—The patient, a man, aged 38 years, had a dislocation of the fifth cervical vertebra, with paraplegia, complete paralysis of the right upper limb, absence of reflexes, etc. The operation was performed about twenty-four hours after the injury. The laminæ of the fifth and sixth cervical vertebræ were removed by bone forceps. The dura mater appeared normal and was not opened. The patient died the following day. At the autopsy, the fifth cervical vertebra was found projecting slightly forward. No fracture was discovered. The dura was uninjured, but the cord was flattened opposite the seat of injury, and was much contused for about an inch above and below, containing hemorrhages in its substance and in the central canal; elsewhere its structure was normal. The first and second bones of the sternum were also partially separated, and the lungs much congested.

CASE II.—A man, aged 33 years, had a fracture of the body of the fifth cervical vertebra which projected backward, distinctly compressing the cord. He was operated upon five days after the injury. A fracture of the fifth cervical spinous process was found so loose that it could be wrenched away in one piece with the left lamina. When this fragment of bone had been taken away the dura was partly exposed, and the right lamina of the sixth cervical arch was also found to be fractured. The left lamina of the sixth arch was then divided and the whole posterior portion of the arch removed. The exposed dura was normal, and was obviously free from compression. During the operation respiration ceased, and the patient's condition became very critical, requiring him to be turned on his back for a time, with the use of artificial respiration and inhalation of nitrite of amyl. The result showed that the spinal cord was here exposed to continued pressure from the displaced bones, and that this pressure must have been relieved by the removal of the counter-pressure due to the excised arches. In spite of this, not the slightest improvement resulted in the symptoms, and it seems not improbable that the operation may have shortened life somewhat, owing to further

damage having been inflicted upon the compressed cord by the necessary manipulations, especially during the period of suspended respiration. The patient survived the operation forty-eight hours.

CASE III.—A man, aged 39 years, after a severe injury, had marked immediate paralysis of sensation and motion in the trunk and limbs, with increased reflexes and anæsthesia extending far up the trunk. He improved for five weeks, after which the case became stationary, except that his general health was affected by a grave cystitis. Fifty-six days after the accident he was, therefore, operated upon. The arches of the fifth and sixth cervical vertebræ were removed. The posterior aspect of the dura was smooth and normal, but the membranes projected somewhat backward, as if distended. The patient died with high temperature and coma eight days later. At the autopsy it was found that the cartilages between the second and third and the third and fourth cervical vertebræ were broken, and there had evidently been severe over-flexion in this region, causing some compression of the upper anterior edge of the body of the third cervical vertebra, but no fracture. The bones had then returned to their positions, leaving the spinal canal free from any permanent compression. The spinal membranes were much congested through their whole extent. The cord itself was soft and diffuent opposite the fourth, fifth, and sixth cervical vertebræ. From these appearances it will be obvious that there had been over-flexion of the cervical region of the spine, and that although the greatest damage to the vertebral column was situated opposite the third cervical vertebra, the cord had suffered mainly from hæmatomyelia opposite the fifth.

CASE IV.—A boy, 15 years of age, with displacement forward of the second lumbar vertebra and compression of the cauda equina. There were paresis of the lower limbs, diminution of sensation, coldness of feet, etc. About four months after the accident he was operated upon. It was found that the arch of the second lumbar vertebra was displaced forward. This was almost completely removed by bone-forceps, exposing the membranes of the cord, which had obviously been compressed by it. Mr. Thorburn remarks that

this case differed materially from the last three, both in the nature of the injury and in the result. The injury did not affect the spinal cord at all, but was confined to the cauda equina, and an interval of four months and a half had elapsed between its receipt and the date of the operation. During the earlier part of this period the symptoms had improved, but, as in the last case, this improvement had ceased, and for some eight weeks there had been no change in the patient's condition. The operation revealed a large amount of cicatricial tissue compressing the nerves of the cauda equina, and on the removal of this tissue improvement recommenced, and was eventually very satisfactory.

CASE V.—A man, aged 28 years, had a dislocation of the last dorsal vertebra, with paraplegia and partial anæsthesia. After slight temporary improvement, the case became stationary. Operation was performed eighteen weeks after the accident. The arch of the first lumbar vertebra was removed, so as to lay bare the dura. The latter appeared to be healthy, although protruding somewhat backward, but between the arches of the first lumbar and the last dorsal vertebra it was compressed by a mass of soft cicatricial tissue. As much as possible of this tissue was removed, together with the whole of the arch of the last dorsal vertebra, and the theca was then found to be so much flattened that its contents appeared to have been quite cut across. Immediately above this region the dura mater bulged slightly, and, a small spicule of bone having penetrated it, some cerebro-spinal fluid escaped. All pressure on the theca being now removed, the skin-flap was replaced and sutured. As in the last case, cicatricial tissue was found surrounding the nervous structures, and this tissue was removed, besides which the cord itself appeared to be almost entirely torn across. The subsequent improvement was practically *nil*, except for a slight recovery of function in the upper lumbar roots, which, having left the cord above the seat of the lesion, form the commencement of the cauda equina.

Mr. Golding-Bird reports (*British Medical Journal*, May 23, 1891) a case of paraplegia from fracture in which he removed the depressed laminæ of the eleventh and twelfth dorsal vertebræ and a large extra-medullary

clot. He operated on the third day after the injury. The patient made a complete recovery, sitting up in bed on the eighteenth day. Mr. Golding-Bird makes the following interesting remarks in reference to the case:

“As in compound fractures of the cranial vault there is a marked difference in respect to treatment between one produced by a heavy blow and another by a sharp-pointed instrument, so in fractures of the spine the line of treatment to be adopted must be determined largely by the manner in which the fracture has been produced. When it can be ascertained that it is due to direct violence, as in this case, it has always seemed to me (and this case bears this view out) that we ought to cut down and explore for bone (lamina) driven on to the cord, just as in a puncture through the skull we always trephine for fragments of the inner table, which are often extensive when the outer wound is quite insignificant. But such cases of direct fracture are not so common as those where, falling from a height, the patient alights on the lower part of the body, breaking the spine higher up, and in such a way that the total upper part overshoots the lower, cutting the cord in two as though by a pair of scissors. In such cases operation can hardly be expected to be of service. But often the history given of the accident is so obscure, and the result of an examination so uncertain, that it becomes a matter of pure speculation whether the paralytic symptoms are due to pressure by a broken arch or by blood-clot, or to division of the cord by a fracture of the vertebral bodies. Cases of spinal fracture are in their results some of the most sad and disappointing that can be met with in practice, for, even when life is saved, the after-condition of the patient is, to say the least of it, almost always most unsatisfactory. Seeing, then, the doubt that usually surrounds the precise nature of the fracture, and knowing what an unfavorable future lies before the patient, a surgeon is surely justified in every case in urging upon the patient the propriety of an exploratory operation, in the hope that the condition found on exposure of the bone may be a relievable one.

“Laminectomy is a recognized operation, and a perfectly safe one, whilst for its performance no special in-

struments are required, though special forceps for cutting the laminae are preferred by some surgeons. This case shows that even two consecutive neural arches may be completely removed without the slightest detriment to the stability of the spinal column. That the patient's paralytic symptoms were not due to 'shock,' but to actual pressure on the cord (and therefore likely to have been lasting had no operation been performed), is shown by the fact that the left side was the worse, and it was two pieces of the left lamina of the twelfth vertebra that overlay each other and compressed the cord. A further argument for laminectomy in spinal fracture is a physiological one, and it indicates the time when the operation should be performed. In limited depressed simple fracture of the skull, though symptoms of compression are present, complete recovery may be seen though the bone is not elevated; but that is no argument for leaving a depressed lamina alone. In the case of the brain, the pressure is exerted over gray ganglionic matter, of which limited parts may be destroyed without permanent loss of function in the periphery over which that ganglionic mass presides; but the spinal cord is mainly a mass of conducting fibres, the destruction of even a minute area of which represents a large area of brain matter 'thrown out of circuit' and rendered permanently useless; hence a degree of displacement of a neural arch appreciable to the examining hand of the surgeon is no criterion of the degree or extent of harmful pressure upon the cord. Inasmuch as nerve-fibres, when divided, begin within three days to degenerate, laminectomy for spinal fracture should be undertaken within that period; for though paralysis from pressure of the cord may exist for much longer and yet be recovered from, thus showing the pressure to have been not too destructive of the fibres of the cord, yet if we wait long enough to judge of the severity of the lesion by the disappearance or not of the paralytic symptoms, we shall certainly have waited too long for operation to offer a chance of success if the latter of these results unfortunately supervenes."*

* In concluding this review of the history of operations for spinal traumatism, I may summarize a portion

Dr. D. N. Knox reports (*Glasgow Medical Journal*, June, 1891) a case in which he trephined for fracture-dislocation of the eleventh dorsal vertebra, which was displaced backward fully three-fourths of an inch, and rotated as much to the right side. The operation was performed thirty-six hours after the injury. The patient was a boy of 13. The laminae of the tenth and eleventh were removed. The dislocated vertebra was replaced. Sensation and motion were both completely lost before the operation, but the former returned the following day, and on the third day he regained slight motion of the toes. The progress of the patient was steadily but slowly towards entire recovery.

In eighty-one cases we find that there were thirty-three recoveries from the operation itself, and forty-seven deaths,—a mortality of about fifty-eight per cent. The older statistics were still more unfavorable, because, first, the cases selected were of the most extreme gravity, and, secondly, trephining opened the way for bony or meningeal infection. The want of success, even since the opening of the anti-septic era, has been due to somewhat the same causes. Pinkerton's case died of operative infection, with a temperature of an acute meningomyelitis. Keetley's had a cervical lesion, and died with pulmonary complications, after having improved for some days. Duncan's case was found at the autopsy to have a diaphragmatic hernia of the stomach and omentum, the result of the severity of the accident. Allingham's case died at the end of seven months, and the cord was found to be completely divided. One of the three patients unsuccessfully operated on by Thorburn had a cervical fracture, with

of another exhaustive article by M. Chipault (*Gazette des Hôpitaux*, 1890, vol. lxiii. pp. 809, 969, 983).

anæsthesia, paralysis of all four limbs, retention of urine and fæces, and very extensive ulceration. He died in forty-eight hours. The second had a fracture in the same region, and of even graver character, and died in twelve hours. The third had also a cervical lesion, and died in eight days, with a high temperature and a suppurating wound. The two patients of Jaboulay were desperate cases at the time of operation.

In those who survived, a varying degree of success was obtained. Werner, writing of seven cases of recoveries of which he knew, and eliminating the case of Blair, which is very insufficiently described, adds: "Trephining in none of the six remaining cases restored the use of the lower limbs to the patients. In the most favorable, feeble motion in the arms and thighs returned, and the sitting position became possible. In all of them sensation returned more quickly and completely than motion. In nearly all of them the vesical functions, and in one case the rectal, were restored."

One patient, that of Edwards, had two children after the trephining. Very recent operations have been somewhat more successful. In the case of Horsley, sensation improved alone. In that of Allingham, paralysis descended to the level of the umbilicus. In that of Dawbarn there was slight improvement in motion and in the rectal and vesical functions. Dandridge and Deces had similar results. Thorburn had one incomplete success, and one so satisfactory that at the end of a year and a half his patient earned his living as a miner and was able to walk many miles daily. Mac-

ewen's patient walked without a cane a year after the operation. Lauenstein's patient at the end of six months could walk all day without a cane, and go up and down stairs easily. Golding-Bird's patient was able to sit up in bed, and apparently was quite well again in eighteen days. Knox's patient regained sensation in twenty-four hours, and a little motion in three days, and was apparently on the road to entire recovery.

The indications and contraindications for trephining in special fractures are, according to Chipault, based on the following points: 1, *the nature of the vertebral lesion and the nature and extent of the medullary lesion*; 2, *the time which has elapsed since the traumatism*; 3, *the regional level of the medullary lesion*. In studying these points only those cases should be included in which the lesion and the operation have been at a higher level than the first or second lumbar, as below that point there are only the bundles of nerve-fibres which constitute the termination of the cord and the cord itself. 1. *As to the nature of the spinal and cord lesions.* a. Of course the spine may be fractured without injury to the cord. In the absence of all symptoms, no one would think of operating. b. If the arches alone are fractured, operation is clearly indicated. c. The propriety of operation is much more doubtful when the spinal lesion affects the bodies also or even the bodies alone. Felizet and other partisans of operating have said that in these cases the cord is compressed between the anterior face of the arch and the posterior face of the fragment of the body; and that if the cord is severed death is certain

at any rate, while if it is not severed operation may result favorably. Chedevergne, on the contrary, believes that the cord is so fixed by the attachments of the pia mater that it is wounded or divided by the anterior fragment, but cannot be compressed between that fragment and the arch. Menard denies this fixity in a study of the mechanism of indirect fracture of the vertebral column in the dorsal and dorso-lumbar regions.

Thorburn has divided vertebral fractures into three classes: 1, those in which after death we do not find the canal notably narrowed, the displaced bones after the accident having resumed their proper position, leaving the cord contused, or even pulped, but free from pressure,—these cases constituting the majority; 2, those in which the displacement is permanent and the cord is compressed; 3, those rarer cases in which pressure upon the cord is due to intraspinal hemorrhage.

In the first of these groups, it must be admitted, all intervention is useless. In the third group, that of hemorrhage into the canal, operation would be of great advantage, but such hemorrhages are very difficult to diagnose. In the second group, which according to many surgeons is the most frequent, Thorburn believes that cure is scarcely possible, as he thinks that the clinical testimony shows that the damage done by acute compression of the cord is usually irreparable. This is contradicted to a certain extent by the experiments of Brown-Séquard and others already quoted. Certainly, however, the most favorable cases are those in which the cord is only partially destroyed or slightly altered: so that

the two great questions which present themselves to an operator in the presence of a fracture of the spine are: 1, Is the cord now compressed by a fragment of bone? 2, has the cord been completely destroyed, partially destroyed, or simply contused?

In regard to the first question, we should examine attentively the deformity, and the relation of the posterior arches and of the articular processes, and can sometimes, but by no means always, arrive at a correct conclusion. As to the second question, the complete disappearance of both sensation and motion below the lesion would indicate the complete transverse destruction of the cord. The disappearance of either one or the other alone, especially when localized on one side or at certain points, indicates a partial destruction. It will be understood, of course, that such localized or partial paralyses after fracture are extremely rare. When they do exist, however, they constitute a valuable guide to the operator.

MacDonald thought that a disappearance of sensation less complete than that of motility indicated medullary compression without destruction. Tillaux thought that the preservation of the muscular sense indicated simple compression. The condition of the reflexes is one of the most important elements in the problem. Tillaux says that while the exaltation of the reflex has been considered as a sign of destruction of the dorsal or cervical cord, he believes that in cases of fracture in the lumbar region its absolute disappearance would generally be a sign of such destruction, because although the cord acts with more vigor beneath the cervical lesion, it could not do the same in the lumbar region, since beneath that there is no cord, so that in lumbar fractures the persistence of reflex action is the favorable sign and its abolition the unfavorable

one. Bastian and Bowlby have recently investigated the same subject. The former found that in two cases of fracture of the spine in the lower cervical and upper dorsal regions there was complete abolition of reflexes; but at the autopsy cord lesions were limited to the level of the traumatism, and the lumbar region presented no change except the secondary degeneration. Bowlby says that he has observed twenty-two cases of cervico-dorsal fracture. In two the reflexes were exaggerated, and the cord was not completely destroyed. In the twenty other cases, of which fifteen were verified by autopsy, and in which the transverse destruction of the cord was complete, the reflexes were completely destroyed, even in one case where the patient lived for ten months.

According to this, therefore, the complete disappearance of reflexes below the lesion would be a valuable sign of complete transverse destruction of the cord.

2. *As to the time between the accident and operation*, both experimental and clinical facts show that the degenerative changes which are set up after a violent contusion or laceration of the cord take place with such rapidity that if *much* time has elapsed a large proportion of cases become hopeless. On the other hand, Horsley's case of tumor, and many cases of recovery from Pott's paralysis, with and without operation, show unmistakably that even long-continued pressure, almost to the point of obliteration, may be followed by a return to normal conditions.

3. *As to the region involved*, both theoretical and statistical considerations show that the lower dorsal and lumbar vertebræ are those which can be operated upon with the greatest hope of success. As to trephining in fractures below the level of the cord, that is to say, below the first lumbar vertebra, the results are,

as might be expected, especially satisfactory. In looking at the statistics collected by Chi-pault, we find in fifty-six cases fifteen cures, of which two were complete (Péan and Lauenstein): the case of M. Péan was, however, a fracture of the posterior arch only. In three of the remaining thirteen (Blair, and Stemen, two) the seat of the lesion is not stated. The case of Alban Smith is without value, on account of carelessness in reporting. In three others (Walker, Potter, and Allingham), the lesions were seated about the lumbar region. In the case of Walker, however, the operation was done on the day following the accident, and it is not certain that a spontaneous cure might not have occurred. There was improvement in the cases of Edwards, Blackman, Gordon, Macewen, Lauenstein, Horsley, Mears, and Dawbarn, in which the lesion affected respectively one of the lumbar vertebræ, the sacrum, the twelfth dorsal or first lumbar, the twelfth dorsal, the junction of the twelfth dorsal with the first lumbar, the eleventh dorsal, the first lumbar, the junction of the last two dorsal. In these eight cases the filum terminale was certainly affected in the first two. In the third and seventh, the terminal portion of the cord was doubtless injured, and the vesical and rectal centres did not participate in the improvement. The same remark applies to the fourth case. In the fifth, the reparative process appeared to have taken place in the cord itself. In the sixth, the improvement was associated with reparation of the nerves of the filum terminale, and not of the cord. In the eighth, the improvement was scarcely noticeable. Thorburn's rule is deserving of consideration in

this connection, but should be contrasted with the remarks of Mr. Golding-Bird apropos of his case of fracture. Thorburn says that for the filum as for peripheral nerves the chances of cure do not seem notably diminished by expectant treatment. Experience shows, he says, that if a spontaneous cure is to take place it will begin early and will be progressive, and he thinks that, therefore, if at the end of six weeks there is no improvement, or if the improvement ceases, operation is indicated only then. In only one of his five cases did he have a complete cure, and then the lesion was confined to the filum, and a considerable quantity of cicatricial tissue compressing its nerves was removed.

I believe I have now given a fairly complete view of the history of this operation in cases of fracture and luxation, and with sufficient detail to permit of a reasonable estimate of its present position before the profession.

The arguments employed against operation in these cases of pressure upon the cord from fracture or displacement may be summarized as follows. It was said that there was great difficulty of diagnosis between the cases in which the operation would probably prove useless and those in which it would probably afford relief on account of the limited extent of the injury. This is undoubtedly true, but a precisely similar argument will apply to many other serious and frequently-employed operations, and all the most recent additions to our knowledge of the subject, whether derived from clinical experiments or from experimental and pathological investigation, lead us to assign to the cord a much greater power of repairing

damage than was formerly thought to be possible.

It was said that the position of the fractured bone often rendered it impossible to reach it, and that the pressure was commonly from the bodies of the vertebræ which could not be removed. A careful review of reported autopsies shows that the proportion of cases in which the pressure is from the laminæ is greater than has been supposed, and that this assertion is as true now as when originally made by Mr. Nunneley twenty years ago.

It is easy to demonstrate that the too sweeping statements which have been quoted, as to the extreme rarity of direct compression by the arches and spinous processes, are not fully justified by the facts. I append a number of references to cases of this character, selected almost at random from medical literature, while seeking information as to other points. They might be greatly multiplied.* They demon-

* Perhaps the following case, recorded by a distinguished neurologist, will serve as well as any as an example of a group of cases which a very little research shows to be by no means infrequent.

Dr. Charles K. Mills has reported (*The Polyclinic*, vol. i., No. 9, 1884) the case of a man who had been crushed by the roof of a building falling upon him; he had motor and sensory paralysis, never recovered, and died of exhaustion five years later.

A post-mortem examination was made thirty hours after death by Dr. Flick. The vertebral column had been fractured at the position of the twelfth dorsal and first lumbar vertebræ. The posterior portion of the upper of these bones had been broken and driven inward, and its fragments were overridden by a portion of the lower injured vertebra. The dura mater was adherent to the bone at the seat of the fracture. In the external layer of the dura, just at the lower end of the

strate that, in addition to the relief which we may perhaps expect to give by removal of the laminæ even in cases of compression by posterior displacement of the bodies, we may expect, in a proportion larger than has been generally supposed, to remove completely and permanently the actual compressing and irritating factor, thus giving the cord an opportunity for reparative action if it has not been

spinal cord, was a bony mass, one-half inch long by one-fourth inch wide. The membrane, for a short distance above this point and down to the cauda equina, was much thickened and covered with a dirty exudation. The cord at this point was red and very soft. The spinal canal contained a large effusion.

Dr. Mills, in reporting this case, said, "This mass which was like the bony concretions sometimes found in the falx cerebri, could have been removed by operation, after elevation of the depressed and broken spinal arch."

He adds, "In another case operation might have been of benefit if performed immediately after the accident. The most important features of this and the first case were as follows. A history of severe injury to the middle and lower spine; this was followed at once by pains in the back and limbs, spinal rigidity, anæsthesia, and paralysis of the lower limbs and of the bladder and bowels. The condition remaining was one of motor paralysis, wasting, contraction, depressed electro-contractility, coldness and lividity, peculiar zones of anæsthesia, and abolition of the tendon reflexes in anæsthetic regions. In this second case, at the upper edge of the twelfth dorsal vertebra adhesions were found which continued down the canal for three or more inches. At the commencement of the cauda equina, which was about the centre of the adhesion, caries of the first lumbar vertebra was found, the portion involved being the inner surface of the laminæ close to the junction of the body. Above and below the caries the adhesions were most persistent. The conus medullaris, cauda equina, and

hopelessly crushed or disorganized,—an opportunity which could not occur if the patient were left to the unaided processes of nature.

Of the cases of resection for fracture and luxation which have thus far been recorded, I find that in no less than forty-five per cent. was there a fracture of the laminæ or processes,—a percentage which, while it is undoubtedly far in excess of the actual frequency of this form of

membranes were a glued mass; for an inch or two above and below this the membrane was considerably thickened, a deposit being present of a calcareous nature ("Spinal Localization," *THERAPEUTIC GAZETTE*, May 15 and June 15, 1889).

Cases more or less similar, but agreeing as to the occurrence of fracture of accessible portions of the vertebræ, have been reported by Astley Cooper; Hamilton, "Fractures and Dislocations;" Stephen Smith, *N. Y. Journal of Medicine*, vol. vi., 1859; Curling, two cases, "London Hospital Reports," vol. i.; Van Dyck, *N. Y. Journal of Medicine*, vol. iii., 1857; Eberman, *Am. Journ. of Med. Sci.*, October, 1879; Arnott, *Lancet*, 1851; Bransby Cooper, *Lancet*, 1828; Williamson, *Dublin Quarterly Journal*, vol. xxvii.; Boyer, "Surgical Works," vol. ii.; C. S. May, *Am. Journ. of Med. Sci.*, October, 1876; Erichsen, "Science and Art of Surgery;" Malgaigne, "Treatise on Fractures" (Packard's translation), *N. Y. Journ. of Med. and Collat. Sci.*, September, 1849, p. 268; Hamilton, "Treatise on Fractures and Dislocations;" "Guy's Hospital Reports," vol. ii. p. 480; F. H. Hamilton, Jr., *American Medical Times*, N. S., vol. viii.; Berkeley Hill, *Trans. Royal Med. and Chirurg. Soc.*, January 22, 1867; Abernethy; J. Comstock, *Boston Medical Journal*, 1848; William Pepper, *Trans. Patholog. Soc. of Phila.*, 1867; T. B. Ladd, *Boston Medical Journal*, 1852; A. P. Clarke, *Journal of the Am. Med. Association*, October, 1884; S. D. Townsend, *Am. Journ. Med. Sci.*, O. S., vol. xxii.; J. Solis Cohen, *Trans. Patholog. Soc. of Phila.* 1878.

fracture, should yet be studied in the light of the statement made by the opponent of the operation,—viz., that it is impossible to tell with accuracy the extent of the damage and the particular parts involved. If this impossibility really exists, it is all the more important that we should not lose sight of the fact that the injury *may* be one quite relievable by operation.

Even when the pressure is anterior, having been caused by displacement or fracture of the vertebral body, removal of the posterior arches increases the calibre of the canal, and increases also the chance of avoiding irreparable damage to the cord by compression. That it is unsafe to say in any given case that the cord is *hopelessly* damaged would seem to be fairly well established by the results of such cases as Horsley's, Macewen's, and Lauenstein's, so that operation should scarcely be refused on that score alone.*

* In his article in "Holmes's Surgery" (vol. iv. p. 130), Alexander Shaw says, "Changes of the most extraordinary magnitude may be effected in the brain and cord by encroachments of various kinds, without the sacrifice of their functions, on condition that the intrusion is made slowly and gradually." This opinion has been reiterated even by surgeons who, like Mr. Shaw, earnestly oppose resection, and is used as an argument for trusting the patient to the *vis medicatrix naturæ*. Professor Eve has brought together (*Amer. Journ. of the Med. Sciences*, July, 1868) eleven cases of supposed division of the spinal cord in which life was variously prolonged, and in one of which recovery was complete. In the lower animals the results of vivisection experiments have been somewhat contradictory, but on the whole sustain the view that the cord, like other nerve-trunks, possesses extraordinary regenerative power. In some animals true nervous matter is introduced after part of

A still further argument was that the exposure of the cord and membranes to the air would inevitably set up a destructive inflammation, an argument which in these days of anti-septic surgery need not further be considered. The general conclusions that the operation was too difficult, was too prolonged, that there was

the cord has been destroyed; at least this is so in tritons and lizards (Müller). As is well known, in these animals when the tail is removed it is reproduced, and Müller found that a part of the spinal cord corresponding to the new part of the tail is reproduced. Morphologically the elements were the same, but the spinal nerves were not reproduced, while physiologically the new nerve-substance was not functionally active. It corresponds, as it were, to a lower stage of development.

According to Masius and Vulain, an excised portion of the spinal cord of a frog is reproduced after six months; while Brown-Séquard maintains that reunion of the divided surfaces of the cord takes place in pigeons after six to fifteen months. A partial reunion is asserted to occur in dogs by Dentan, Nannyn, and Eichhorst, although Schieferdecker obtained only negative results, the divided ends being united merely by connective tissue (Schwalbe).

Eichhorst and Nannyn found that in young dogs, whose spinal cord was divided—not excised—between the dorsal and lumbar regions, there was an anatomical and physiological regeneration to such an extent that voluntary movements could be executed. Vulain in the case of frogs, and Masius in that of dogs, found motility restored first and sensation afterwards.

In 1882, Dr. Carl Maydl, of Vienna, conceived the project of resecting the whole thickness of the cord, and, after some successful experiments on dogs, actually opened the spinal canal of a man for that purpose, but found the conditions too unfavorable to proceed further. The patient recovered from the operation, but was not improved at all.

danger of fatal hemorrhage, etc., were, as experience has shown, largely theoretical; and although the operation is certainly not an easy one, and although one operator did lose his patient on the table from hemorrhage while attempting to perform it, it is still one which may be confidently undertaken by any experienced surgeon.

In reviewing the statistics of these operative cases, it seems to me quite proper that those belonging to the pre-antiseptic period should be omitted, or should be regarded in a category by themselves. I do not mean that all, or even a majority, of the fatal cases were due to septic disease. In many of them the time was too short, in others death resulted from intercurrent disease of other organs; but a sufficiently large proportion were so distinctly septic as to invalidate any sweeping conclusions based upon the results, sepsis after this operation being as absolutely avoidable as after any other in surgery. This would leave, then, in a class by themselves, the thirty-seven operations for fracture of Macewen, Morris, Horsley (two), Lauenstein, Lucke, Albert, Duncan (three), Péan, Allingham (two), Dawbarn, Mears, Thorburn (five), Dandridge, Deces, Jaboulay (two), Abbé (three), Pilcher, Manley, Bell (two), Armstrong, Halstead, Pinkerton, Golding-Bird, Richardson, Knox, with six complete recoveries, six recoveries from the operation with benefit, eleven recoveries unimproved, and fourteen deaths,—a mortality of thirty-eight per cent.

The chief strength of the opponents of operation lies in the argument that the operation *per se* is of great danger, or in itself materially

diminishes the patient's chances. If, as I believe to be the case, it can be fairly claimed that rapid reunion of all the soft structures down to the dura mater itself can be confidently expected ; if it can be shown, as it has been, that extensive resections of the laminæ do not greatly or permanently weaken the spine ; if under antiseptic methods the risk of consecutive inflammation of cord or membranes is practically *nil* ; if hemorrhage is not to be feared, and if loss of cerebro-spinal fluid is unimportant ; if it happens not so very infrequently that the cord is directly compressed by fragments of the laminæ themselves, or, if not, that by removal of the arches relief from anterior pressure *may* be afforded,—if these are facts, or even reasonably strong probabilities, it is evident that the operation is one which should no longer be rejected on the sole remaining ground that we cannot be certain in any given case as to the exact amount of damage which has been done to the tissues of the cord. The argument that, if such damage were irreparable, operative interference would be useless, while if the cord retained the power of recovering itself the operation would only add another complication, has lost nearly all its force. It would seem rather to be the duty of the surgeon, after a reasonable and not very protracted delay, to endeavor to relieve any possible pressure, to remove any fragments or spiculæ of bone, to drain thoroughly the canal or even the subdural space if there be any oozing, and to do so with the consciousness that, if he meet with none of these conditions, he is at any rate not performing a necessarily fatal operation.

Chipault comes to the following conclusions: 1. Trephining is useless when, the cord having been contused, the fragments displaced at the time of the traumatism have returned to their normal position. 2. Trephining is almost certainly useful (*a*) when the cord is compressed between a vertebral body and a posterior arch; (*b*) when there is medullary compression from spinal hemorrhage. In these two conditions the least possible delay is advisable, on account of the extreme rapidity with which secondary degenerations occur.*

* "I might give many illustrations gathered from medical and surgical literature of intraspinal hemorrhage in which operation would probably have proved successful, but I will confine myself to two, one twenty-two years old and the other a recent case.

"Jackson (*Lancet*, July 3, 1869) reported an interesting case of localized spinal apoplexy, which with our present lights might perhaps have been relieved and a life saved by careful trephining. The patient was a bright girl, 14 years old. While dressing, her fingers felt weak. The next day she had a similar weak feeling in her hands. One day later she was unable to move her arms except at the wrists. Later, the intercostal muscles did not act quite freely, and she seemed to lie heavier in the bed. Moist crepitant râles, with a little cough, developed. On the fifth day after the first symptoms, careful examination clearly demonstrated great loss of power in all the voluntary muscles of respiration and in those muscles of the arm, back, and chest supplied by the cervical nerves. The diaphragm became fixed, and there was slight lividity about the cheeks, with a fall in the natural temperature. Sir W. Jenner, who was called in consultation, diagnosed a clot in the cervical portion of the spinal cord. The whole cervical portion of the spine, but particularly in front and to the left, was embedded in an oblong clot of dark venous blood outside the membranes. The clot ceased at the seventh cervical vertebra.

"In this case, as the reporter remarked, the effusion probably took place very gradually, had room to extend itself, and coagulated very slowly and imperfectly.

3. Trephining is absolutely indicated (*a*) when the symptoms are due to compression of the cord by fragments of the arches or laminæ; we should then operate as early as possible; (*b*) when there is compression of the filum terminale from any cause,—that is, from either anterior or posterior fracture or from the presence of cicatricial tissue. We should operate at the end of the same month if improvement has ceased for a few weeks.

Unquestionably, if for any of the above reasons we decide to operate, the earlier the operation is done the greater the probability

Until the phrenic nerves were interfered with, nearly every symptom might have been attributed to hysteria.

“The following case was reported by Dr. Arlidge to the Staffordshire branch of the British Medical Association (*Med. and Surg. Rep.*, March 23, 1889, vol. lx., No. 12, p. 370). The patient, 44 years old, a drinking man, was admitted to the infirmary with complete motor paralysis of the legs and some weakness in the arms, where, too, formication and numbness were experienced. Sensation was normal, and the legs were painless and their reflexes abolished. His only complaint was of dorsal pain. The bladder was distended, and prior to admission had been emptied by the catheter, but there was no dribbling of urine. Some bronchial râles were noted in the upper part of the left lung; heart healthy; bowels confined for four days; the cerebrum undisturbed. The first temperature taken was 103.6°, but the next day it fluctuated between 105° and 106°, and rose to 107.4° the day preceding his death, and was accompanied by delirium. A post-mortem examination revealed a copious hemorrhage within the meninges of the spinal cord, extending downward from the last cervical vertebra for about six inches. The blood was coagulated. No ruptured vessels were found in the cord itself, and no cerebral disease, although the dura mater was very adherent to the skull. There was no fracture of the spine, and no caries of any vertebra” (Chas. K. Mills, “Spinal Localization,” *THERAPEUTIC GAZETTE*, May 15 and June 15, 1889).

that it will be of benefit. In the presence of depression of arches or laminæ, immediate interference is justifiable, as it is in cases with recognizable symptoms of spinal hemorrhage. In the absence of these conditions, and weighing fairly the fact that even in recent times and in good hands there have been but seventeen per cent. of complete recoveries and a mortality of thirty-nine per cent. after this operation, the safest rule with which I am familiar is that which has been formulated by Lauenstein,—namely, that if after the lapse of from six to ten weeks there is incontinence of urine, with cystitis or incontinence of fæces, and especially if there is also the development of bed-sores, little is to be hoped for from the unaided efforts of nature. If, however, these symptoms be absent, and if there be the least improvement in either sensation or motion, it will be proper for the surgeon to delay operative interference still longer.*

* All operators upon cases of fracture paraplegia of any duration have thus far arrived at about the same conclusion,—namely, that the pressure of bone is of secondary importance, except the fracture involves only the arch, where it is driven in by a blow, inasmuch as the violence, usually a fall and bending of the back, which will produce instant paralysis, has done so by a diastasis of the vertebræ, the cartilages being ruptured and the arches broken, which completely pulpifies the spinal medulla. The vertebræ are very apt to resume immediately their usual relations. If, however, the fracture takes place at or below the last dorsal, where the medulla has disappeared and the firm cauda equina commences, the crushing does not usually destroy the nerves, but long bone-pressure would do so. In such cases operation to correct it is always desirable. It still remains a problem, perhaps never to be solved, how to connect the

In conclusion, I desire to speak briefly of the operation itself, which has been variously described as "formidable," "appalling," "well-nigh impossible," "desperate and blind," and

lower segment of the cord with the upper when there is a gap of half an inch, and whether this union would restore functional connection with the brain, even though its reflex and independent activity might be ever so good. The cases may yet be found where sufficiently narrow transverse lesions will allow the suturing of fresh-cut ends of the cord.

In other cases it remains yet to try the suturing of nerve-roots from above the breaks into some one or two below, sacrificing only the cutaneous supply for a small area, as suggested by Dr. Dana, or, as seems feasible, implanting them into the cut end of the lower stump, thus perhaps innervating some limited portion of the distal end with the chance of stimulating more. Possibly in this way even the vesical control alone might be restored. This is conjecture entirely, and is based on the fact that clean-cut nerve-sections will unite" (Robert Abbé, *New York Medical Record*, vol. xxxviii., 2, pp. 85-92).

Dandridge remarks that "the question of operative interference in spinal surgery must be considered in reference to interference immediately after the receipt of injury, and interference deferred until the amount and character of permanent disability can be determined. The solution of these questions involves a consideration of the source and results of fracture treated without recourse to operation. It is well known that not only a considerable number of these cases escape death, but entirely recover all their functions, even after the existence of paralysis, incontinence, and bed-sores existing for a variable length of time. In a valuable paper Burrell has investigated the results of all the cases which have occurred in the Boston City Hospital, eighty-one cases in all, of which eighteen survived. Divided into regions, we find twenty-eight cases of fracture of the cervical vertebræ gave two recoveries; twelve cases of fracture of the upper dorsal vertebræ, six recoveries; nineteen cases of fracture of the lower

in other similar extravagant terms. In one case the patient is said to have died on the table from hemorrhage; in another the operation was abandoned on account of the supposed impossibility of its completion. It has not seemed to me that these descriptions are in the least justifiable. The operation is, indeed, as was said by McDonnell, apt to be tedious and tiresome; but, so far as any major difficulties are concerned, it is not to be compared with many much better known, and much more frequently practised, operative procedures. I

dorsal, one recovery; twenty-three cases of fracture of the lumbar vertebræ, ten recoveries. Of the sixty-four fatal cases thirty-five died within five days, eight in from five to ten days, and seven in from ten days to a month. Five of these cases were submitted to operation,—all of which were promptly fatal. In the eighteen who survived, the result was good in nine, and in nine complete disability remained permanent. The especial value of Burrell's paper is that it is based on the entire number of cases treated in a single institution, and gives, therefore, more reliable data for deductions than statistics made up of isolated cases. Favorable results always obtain undue prominence under such circumstances. It is apparent from the above figures that twenty-one per cent. of fractures of the spine survive, and that over ten per cent. make a satisfactory recovery.

“Of the fatal cases, a very large proportion die in the first few days,—a fact of importance in estimating the danger of operation, the high mortality of which in cases of recent injury cannot properly be attributed to the operation itself, but is largely due to the concomitant injury.

“It is further evident that, while treatment is successful in preserving the lives of a considerable number, one-half the survivors are left completely disabled: so that any addition to our therapeutic resources must be eagerly welcomed” (*Journal of the American Medical Association*, 1889, vol. xiii., 2, pp. 39, 40).

base this opinion both upon experiments on the cadaver, and upon my experience with the cases in which I have performed resection. It may be useful to give the details of the method which seems to be preferable :

The patient having been placed in the prone position, and a gentle curve having been given the spine by means of a firm, small pillow placed under the lower ribs, a long incision should be made directly down to the tips of the spinous processes, the middle of the incision being opposite the supposed site of the tumor, the apex of the angle, or curve, if the case be one of Pott's disease, or the deformity, or displacement, if the case be one of fracture or luxation. The muscles should then be freely separated from the sides of the spinous processes and the posterior surfaces of the laminæ, the edge of a stout, thick-backed scalpel being used for this purpose. One side of the spine should be cleared, and all hemorrhage arrested by the use of hæmostatic forceps, before the other side is approached, and the wound should be filled with sponges, or a towel wrung out of a hot antiseptic solution. This having been done, the other side may be treated in the same manner. By the time the spine is thoroughly exposed on the second side, most of the bleeding will have permanently stopped on the other ; but any distinct spirits or free oozing following the removal of the catch-forceps should then be permanently arrested by ligature, after which the periosteum may be reflected by making a firm incision through it along the angle between the spinous processes and the laminæ, turning up its edge at this point with the help of dissecting forceps, and then scraping the surfaces of the vertebral arches with a curved periosteal elevator. This being completed, the hemorrhage should be similarly arrested, and the periosteum reflected on the opposite side. Cline and Tyrrell used broad angular plates as retractors on each side ; Gordon divided the attachment of the muscles to the articular processes, which, he said, gave plenty of room, as each end of a muscular bundle when separated from its attachment retracted of itself and needed little

holding back with the fingers; Horsley divides the deep fascia at right angles to the line of the incision opposite its middle, in order to prevent its resisting a proper separation of the sides of the wound, and says that it may be found necessary to divide this aponeurosis at more places than one. In my cases I found that retractors of moderate size, not large or clumsy enough to be in the way, were all that was needed to keep the muscular masses from interfering with the subsequent procedures. The next step, and one which greatly facilitates the remainder of the operation, consists in the division of the spinous processes close to their bases by means of large, strong bone-forceps set at an obtuse angle. That was not done by most of the earlier operators, but it certainly adds nothing to the severity of the operation, while affording much freer exposure of the laminæ, which are the next parts to be attacked. In perforating these, Cline advised the use of a small crowned trephine to cut through the vertebral arches, if requisite,—that is, if they were not already broken into more than two pieces. Tyrrell found Hey's saw most convenient. In Gordon's case one side of the arch was broken and the yellow ligament torn through, admitting the entrance of his finger, so that he merely divided the other side of the arch with a pair of stout bone-forceps; Lauenstein employed a chisel; Horsley returned to the use of the trephine, but says that if more than one arch is to be removed it will be better by means of an angular saw to cut partly through the laminæ along the lines of the sides of the neural canal, and then the division of the bones can be completed with the bone-forceps. I have found that both the trephine and the saw are unnecessary, and that the laminæ can be more expeditiously, and with equal safety, divided by the use of a pair of very strong bone-forceps, either straight or having a large obtuse angle, as may be preferred by the operator. The vertebra at the centre of the incision should be selected, and the vertebral spaces above and below its laminæ should be recognized with the tip of the finger. The points of the bone-forceps should then be placed above and below its edges, and the laminæ cut through by successive short nips, the line of section being as close to the transverse processes as possible. This gives

the greatest exposure of the cord and of the membrane itself.

Abbé's procedure is as follows. The patient is laid prone, but with one shoulder raised by a sand pillow,—favoring easier respiration and inclining the back towards the operator slightly. A free incision is made parallel to the spines and a half-inch to one side, cutting the longitudinal attachments from one side only, and being carried clean down to the laminæ at the second or third pass of the knife. To approach the fracture the incision is made from one or two vertebræ above to an equal distance below; the laminæ are then cleared of muscles, which are drawn outward by retractors, and the ligament divided so as to isolate a block of four spines, whose bases are then severed from their arches by stout cutting pliers.

This manœuvre at once allows a retraction of the entire block of connected spines with their muscles still attached to one side, and the entire breadth of the spinal arch is thus exposed without sacrificing the overlying tissues. A pair of slightly-curved rongeurs are then applied to the lower edge of one lamina, and with incredible ease the entire breadth is quickly gnawed away.

Abbé claims that this is the most speedy, the least bloody, preserves all the tissues in and about the spines which are replaced, and gives firmness to the back, as well as prevents a gap that nature would be obliged to fill. The incision should be on one side of the spines only, they being cut off and dragged to the other side, exposing the entire arch without dividing the inter-spinous ligament. The only bone-cutting instruments to be used are two very narrow rongeurs, one curved, one straight, with a quarter-inch bite and presenting a flat Gothic arch aspect when the points are brought together. Abbé thinks that the saw is dangerous, awkward, and inefficient, and that the rongeurs are by far the quickest.

The color of the dura should be noted, particularly with the view of determining in cases of traumatism whether it is or is not necessary to open it. If it be dark or purplish from the presence of exuded blood beneath it, or yellowish from the presence of pus, it will, of course, be proper to incise it in order to empty and

to explore the subdural space. My own feeling is that in all cases in the future in which this operation is performed for supposed tumor, and the growth is not found lying upon or external to the dura, that membrane should be freely and fearlessly opened for exploration purposes. The resulting escape of the cerebro-spinal fluid has been found to be merely one of the bugbears of the subject, and is certainly not to be weighed against the chance of terminating the operation without discovering a possibly existent and relievable condition. If it is determined to open it, it may be picked up in the median line and at the middle of the incision with a pair of delicate toothed forceps, nicked with a knife or the scissors, and then divided either upon a director or with a pair of blunt-pointed scissors to any required extent upward or downward. It can be easily and gently retracted to either side, so as to expose the whole posterior surface of the cord to both inspection and palpation, permitting the gentle insertion of the tip of the finger between its inner surface and the lateral aspect of the cord, and permitting also, if need be, the investigation of the anterior and antero-lateral subdural spaces by means of a blunt curved instrument, such as a pedicle needle or an aneurismal needle. The inspection having been completed, the tumor having been removed, and the pus or blood evacuated, or it having been determined that no indication for further operative interference exists, the incision in the dura should be stitched up with fine interrupted catgut sutures. These may be introduced very readily and speedily by means of a pair of staphylorrhaphy needles, the one not in use being threaded by an assistant while each stitch is being put in place; the stitches should be inserted at intervals of about one-eighth to one-sixth of an inch, and when all are in place can be easily tied, the ends being cut off short. A small rubber drainage-tube and a dozen strands of chromicized catgut should then be laid throughout the entire length of the wound, the muscles being united above them by means of chromicized catgut sutures, after which the skin and aponeurosis are brought together by silk or silver wire, as may be preferred. It is hardly necessary to say that the most rigid antiseptic precautions should be observed from first to last.

I may, in conclusion, briefly summarize the opinions I have arrived at after this consideration of this last branch of the subject.

1. Some objections urged against operative interference in spinal traumatism—*i.e.*, hemorrhage, frequency of absolute destruction of the cord, pressure from inaccessible fragments of bone, etc.—have been shown to be unsupported by clinical facts; others were largely due to a well-founded dread of (*a*) the shock in those cases operated on in pre-anæsthetic times, and (*b*) consecutive inflammation, supuration, and pyæmia in pre-antiseptic periods.

2. The results of recent operative interference in properly-selected cases of fractures of the spine are encouraging, and should lead to the more frequent employment of resection of the posterior arches and laminæ: (*a*) in all cases in which depression of those portions, either from fracture or from dislocation, is obvious; (*b*) in some cases in which after fracture rapidly progressive degenerative changes manifest themselves; (*c*) in all cases in which there is compression of the cauda equina from any cause, whether from anterior or posterior fracture or from cicatricial tissue; (*d*) in the presence of characteristic symptoms of spinal hemorrhage, intra- or extra-medullary.

3. Operation is contraindicated by a history of such severe crushing force as would be likely to cause disorganization of the cord. The question which will remain in doubt previous to operation will usually be that of the extent of damage done to the cord and the possibility of its taking on reparative action. As to this, the safest rule is that which has been formulated by Lauenstein,—namely, that

if after the lapse of six or ten weeks there is incontinence of urine with cystitis, or incontinence of fæces, and especially if there are also the development and spreading of bed-sores, but little is to be hoped for from the unaided efforts of nature. If, however, these symptoms be absent, and if there be the least improvement in either sensation or motion, it will be proper for the surgeon to delay operative interference still longer.